The UNESCO COURIER

NOVEMBER 1993

INTERVIEW WITH AMOS OZ

THE STORY OF NUMBERS

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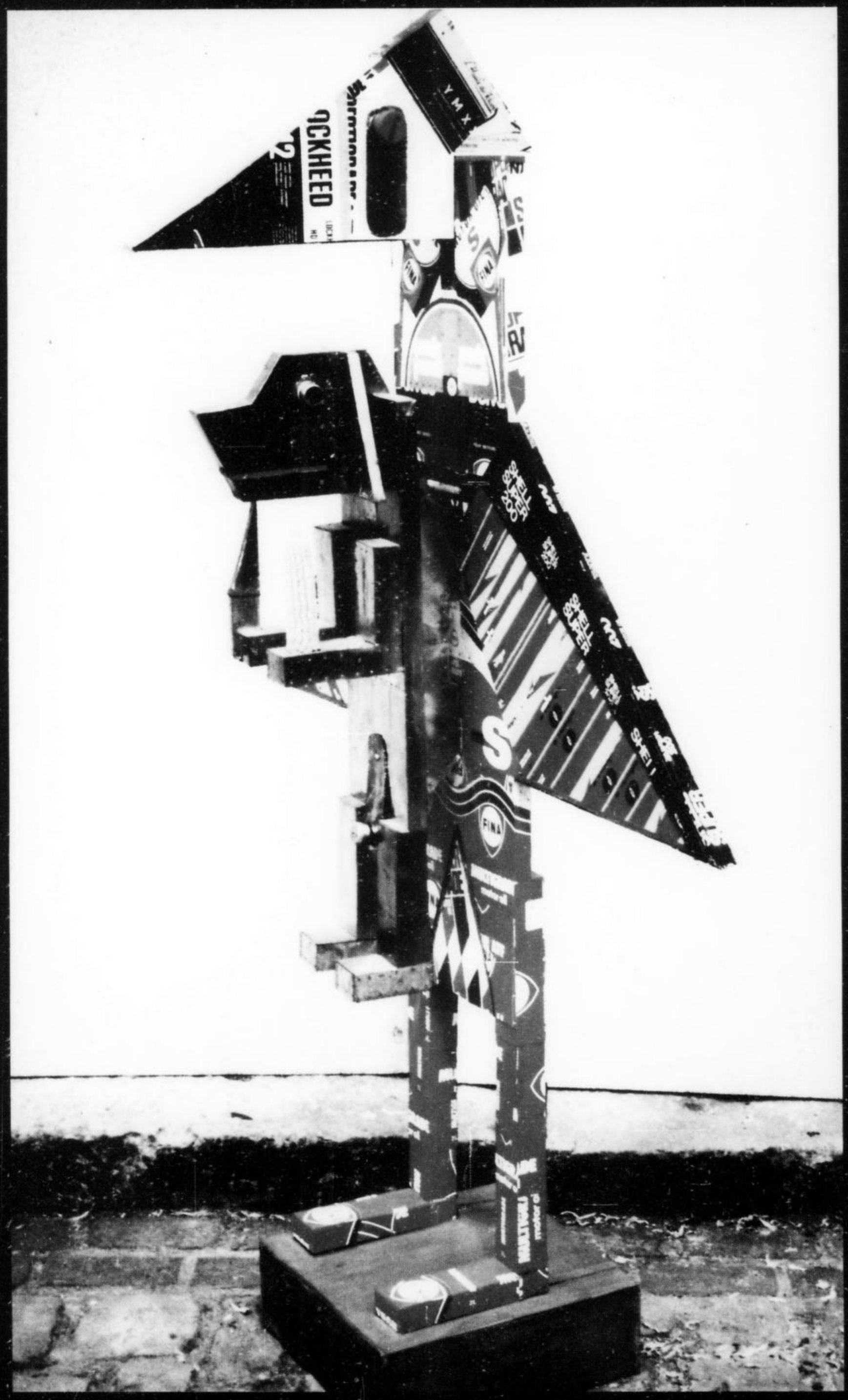
ENCOUNTERS

We invite readers to send us photographs to be considered for publication in this feature. Your photo should show a painting, a sculpture, piece of architecture or any other subject which seems to be an example of cross-fertilization between cultures. Alternatively, you could send us pictures of two works from different cultural backgrounds in which you see some striking connection or resemblance. Please add a short caption to all photographs.



QUETZALCÓATL AND XOLOTL

(1991) sculpture in wood and metal (height 1.70 m) by Georges Tardy

Quetzalcóatl, the Plumed Serpent, one of the great gods in the Aztec pantheon, is here depicted with his companion, the dog-headed god Xolotl. They represent the forces of life and creativity. According to an Aztec myth, the two of them descended into hell to gather the bones of the ancient dead, anointing them with blood and thereby giving birth to those who inhabit the present universe. The artist has covered the wood of his sculpture with pieces of metal from motor oil cans in a symbolic allusion to industrialized societies in need of regeneration.

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Figure 5 (1960) by the American painter Jasper Johns.

Special consultant for this issue:
Tony Lévy

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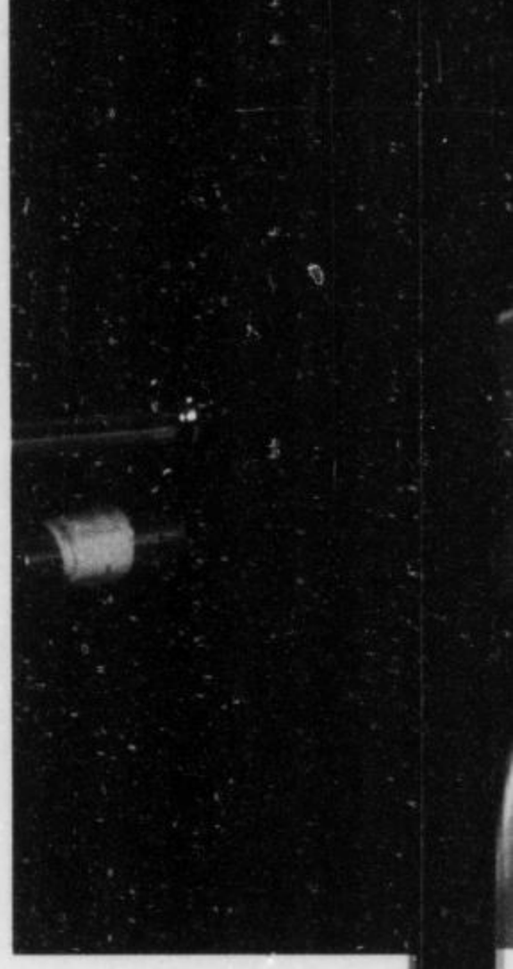
"The Governments of the States parties to this Constitution on behalf of their peoples declare,
"that since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed ...
"that a peace based exclusively upon the political and economic arrangements of governments would not be a peace which could secure the unanimous, lasting and sincere support of the peoples of the world, and that the peace must therefore be founded, if it is not to fail, upon the intellectual and moral solidarity of mankind.
"For these reasons, the States parties ... are agreed and determined to develop and to increase the means of communication between their peoples and to employ these means for the purposes of mutual understanding and a truer and more perfect knowledge of each other's lives..."
EXTRACT FROM THE PREAMBLE TO THE CONSTITUTION OF UNESCO, LONDON, 16 NOVEMBER 1945

Amos Oz talks to Edgar Reichmann



Amos Oz, who was born in Jerusalem in 1939, is widely acknowledged to be one of the most gifted Israeli writers working today. His novels and collections of short fiction, which have been translated into many languages, include *Elsewhere, Perhaps* (1966), *My Michael* (1968), *Touch the Water, Touch the Wind* (1973) and *The Hill of Evil Counsel* (1976). His *In the Land of Israel* (1983) is a book of reportage based on interviews with Israelis from different backgrounds. A committed writer, Amos Oz has always worked for a rapprochement between Israelis and Palestinians. His latest novel, *Fima*, has just been published by Chatto & Windus, London.

EDGAR REICHMANN
is a novelist and literary critic.

■ *You write in Hebrew, which is not a widely read language. How do you explain the fact that your work has an international readership?*

—My books have been translated into twenty-six languages, including Japanese and Catalan. I speak only Hebrew, which is my mother tongue, and English. I've always wondered what a reader on another continent, steeped in a culture so different from my own, might feel on reading my books. I think reading a book in translation is like making love to someone through a window or playing a violin sonata on the piano. However good the translation, something is always lost. Granted, everything hinges on the translator's generosity and intelligence. A translator should not slavishly follow the syntax of the original text but focus on the meaning and the melody of words and transpose as well as possible their music and scansion.

My parents, who were born in Russia, spoke Russian and Polish to each other, read German, English and French, which opened the doors of Western culture to them, and probably dreamed in Yiddish, since they were Jewish. But when between the wars they came and settled in what was then the British mandate of Palestine, they adopted Hebrew and decided to speak to me only in Hebrew, if only to prevent me, someone who was so drawn to the "elsewhere" that had brought them so much disappointment, from being tempted to leave the country.

My father studied comparative literature. It's because of him that I started to read the great writers, the ones who ask the fundamental questions that are asked by men and women all over the world.

The concept of universalism may seem vague and sometimes irrelevant. One might well ask how an Australian or an Argentine reader can have the same centres of interest as an Egyptian or Pakistani reader, for example. How can one find the secret way from the particular to the universal? Great Russian writers like Dostoyevsky or Chekhov, Israeli ones like Agnon or Brenner, and central European writers such as Musil and Mann have managed to transcend historical and cultural differences and religious and political commitments.

■ *Your works are peopled by nostalgic, uprooted characters at grips with painful inner conflicts and in search of an "elsewhere" that is hard, if not impossible, to find. Are these personal dramas metaphor-*

ical expressions of those rocking your country?

—Authors from the world's trouble spots are often suspected of using metaphor to express their political commitments. To me, political reality is a metaphor for personal or family conflicts. The issue that preoccupies me most is the durability of the family, the most fantastic, the most mysterious and the oldest of our social institutions. Man and woman have not always been monogamous, far from it! Their love never lasts forever, whether it is carnal, based on pure affection or has the form of a loving friendship. And yet the family has survived throughout history, indestructible in spite of many social upheavals. Why? I have tried to answer this question in all my novels.

As far as the links between novels and politics are concerned, I am amazed by the importance some European readers have attached in the last half-century to "deciphering" all forms of literature in terms of current events. If Melville had written *Moby Dick* today, commentators would see Ahab as some kind of dictator who wanted to destroy individual freedom as embodied by the mythical whale. In the West there is too much of a tendency to read politics into writing that has nothing to do with current events. Even in countries and regions where the situation is particularly tense, family life goes on, with its joys and sorrows, births, unresolved conflicts, divorces and reconciliations. Although violent death is common in this world that has gone astray, spring follows winter and the trees blossom anew.

■ ***Some of your characters are fanatics. I am thinking of the fundamentalist Michel Sommo and the intellectual Alex Gideon in* Black Box. *What do you think of fanaticism?***

—I am a son of Jerusalem, which is the womb and home of all the monotheistic religions, a city where the devout live side by side with unbelievers and where very different communities live a few streets away from each other. And so I've seen fanaticism erupt in all its horror. I have also seen fanaticism elsewhere, in other forms and in other guises. I think fanaticism is the supreme fascination that death exerts on some people, an urge that compels them to give it and receive it.

The true fanatic is not content to sacrifice his own life. He must destroy his opponent first. He does not exist as a private individual; he is always representing something, ready to sacrifice his family as well as himself for a cause that must come first. But it is not the "cause" that triggers the fanatic's murderous deeds, but fanaticism itself, which is a kind of disease. "Great causes" come and go, but fanaticism remains.

Think of the incredible changes that have happened in what used to be the countries of the communist bloc. We see the dyed-in-the-wool communists of yesterday become today's ultra-nationalists, former anti-clerical militants impose strict religious observance and vice versa. A few decades before, in central and eastern Europe, we saw former Nazis turn into communist torturers. And they were not only driven by opportunism. No matter which ideology they were defending, they showed the same enthusiasm and loyalty. They were true fanatics, driven as much by temperament as by choice.

I believe that peace and human happiness are more important than the tragic options of the heroes of Antiquity.

Alex Gideon, the hero of *Black Box*, is a specialist in the human sciences who is doing research into fanaticism at an American university institute. Like a researcher contaminated by the virus he is trying to isolate and fight in the laboratory, Gideon becomes infected, in his relationship with his ex-wife, with the virus he is working on. He becomes self-absorbed, spiteful and vindictive.

■ ***In* Knowing a Woman *an Israeli secret agent decides to retire after his wife mysteriously dies and asks himself painful questions about the meaning of his life. Is this the work of a moralist or an opportunity to say something about the human condition?***

—In this novel I turned my attention to the riddle in our fellow man, an enigma that is not always where one might think it is. It seems as if nothing is going on. I took the spy out of the spy novel setting. My hero, a secretive man and a loner, explores his own past and that of his dead wife and their daughter, an epileptic. Is he responsible for his wife's disappearance, his daughter's affliction and the death of a colleague who took his place on a mission? These questions are not answered, of course. Death and loneliness are the main characters in this book, which is a journey of initiation towards self-knowledge. But the ethical dimension is still there in the form of theological questions—about the nature of good and evil, for example. Does the Dostoyevskian framework of *Crime and Punishment* still work? In real detective novels the reader always ends up finding out who the murderer and victim are. In this one, the reader may be invited to look into himself or herself.

■ ***These issues crop up again in* Fima, *where the main character, whose personal and social aspirations have been thwarted, seeks refuge in the "third state", the area in which man comes face to face with eternity. Is this due to despair?***

—I conceived this book as a sort of theological comedy. My character Fima is a real schlemiel, the comic hero of Yiddish folklore whose head is always in the clouds and to whom the most incredible things happen because he mixes up dreams and reality. When Fima's father dies, bringing to an end a long Œdipal conflict, he takes refuge in this third state. Like most people who live in Jerusalem, Fima is also a kind of minor prophet with his eyes on the stars, in search of some mysterious revelation.

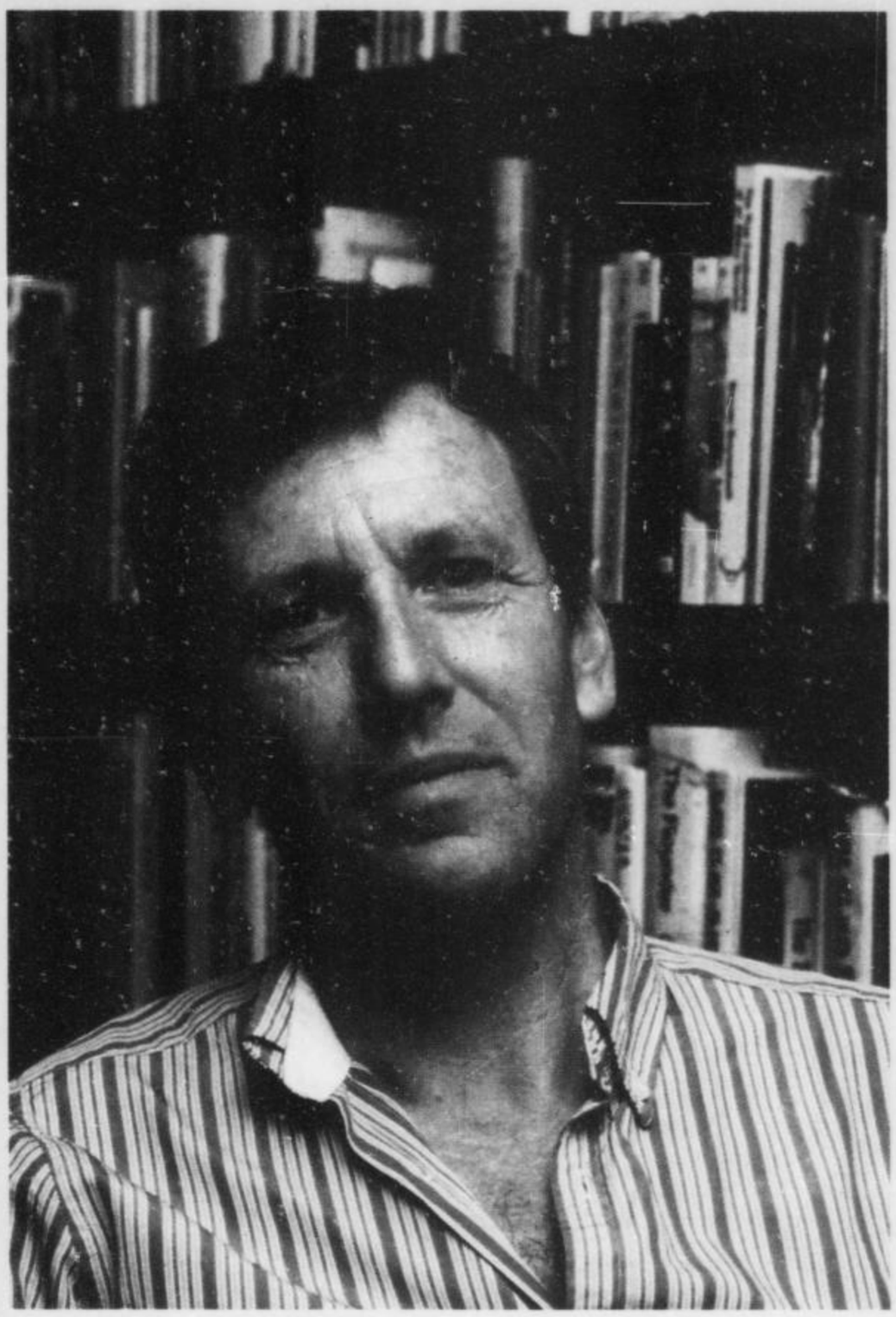
He is trying to find an improbable harmony in which all the dissonances of real life would melt into symphonic chords. He would like to reconcile the irreconcilable. Narcissistic, like so many intellectuals, he would like to be loved by every woman and would like all women to love each other through him. For Fima, the third state is the place where there are no more decisions to be made. He flees to a distant, heavenly Jerusalem. He is a good man who, alas, cannot manage to do anything good.

To him Jerusalem is burdened with a guilt that he makes his own. Like Christ, he takes on all the sins of the world. He feels personally responsible for the *intifada*. Like some of Chekhov's characters, he is full of good intentions. If he can't manage to translate them into deeds, it's because circumstances are stronger than he is.

■ ***Your love for Jerusalem is a recurrent feature of your work. Are you for Jerusalem what Svevo was for Trieste or Joyce for Dublin?***

—I grew up in Jerusalem in a working-class environment where each individual, no matter how humble, was transformed into a prophet or political scientist. Our grocer rebutted Marx with arguments taken from Hegel, and around the end of the Second World War the milkman wanted to put forward a detailed plan to change the direction of British policy in Palestine, which was then under the mandate. Later, my dentist, who came from Russia and was a bit of a mythomaniac, claimed to have known Stalin personally.

We kept open house and our neighbours came to talk to my parents about Sartre and communism, America and our chances of living in peace with our neighbours. Everyone argued in favour of his or her positions and I, little more than a child, thought they were all right, like Fima. I was often driven to despair by the tragedies caused by the fanaticism that repeatedly caused bloodshed in our city. I was Fima, but I was also the little guy with the bicycle, the hero of my children's book who rides through the city with his heart full of bitterness and hope. "When you can't cry any more, then laugh," my grandmother used to tell me. That's why I have faith in humour. When I was a child there was one particular joke that I loved—it baffled me every time I heard it. Two men arguing about which of them owns a piece of goods ask a rabbi to say which of them is the rightful owner. The rabbi listens to the first man and then gives judgment in his favour. Then he listens to the second man and comes down on his side too. Back home he tells the story to his wife, who says, "How on earth could you have decided that both of them were right?" "Well, I guess you're right, too," he replies. I think this story is still valid today.



Jerusalem has taught me about the unfathomable depths of relativism, the tragic dimensions of the human comedy but also the comic aspects of that tragedy. I have never seen a fanatic with a sense of humour, and I have never seen anyone with a sense of humour turn into a fanatic. As a peace-loving Israeli novelist, the highest reward I aspire to is the Nobel Prize for medicine. I'll get it the day I manage to put a sense of humour into capsules and administer it to people all over the world so as to immunize them against fanaticism. The elevator to the third state will always be humour.

■ ***For decades you have been not only a novelist but a peace activist as well. What do you think of the latest developments?***
—With the mutual recognition of the Israeli government and the PLO, and the conclusion of the accords on the autonomy of Gaza and Jericho, the illusion of a "Greater Israel" has finally evaporated, and so has the dream of those who wanted to send the Jews back to their countries of origin. However, in this historic autumn of 1993 we have not yet reached the end of the road. Let's say that today we are at the "end of the beginning" together. Jew and Arab, who are living on the same land, are leaving behind them the memory of endless suffering. After this beginning, punctuated by so many wars and so much suffering, we can see the first glimmer of hope.

But while the lucid, level-headed positions of the Israeli and Arab peacemakers are now inspiring the talks between the Israeli government and PLO leaders, the time for rejoicing has not yet come because we are still steeped in mistrust and fear. Waging war is difficult, but building peace is just as arduous in a different way. Once the foundations for understanding between our two peoples are laid, mentalities must change and peace must be made to reign in these streets where the cries of extremists can still be heard. It's possible. It has already been done. The wars between France and England went on for centuries, not to mention the slaughter between the Germans and the French. Today these peoples get along so well with each other that they're building the European Community together.

The mirage of total justice brings blindness, grief and death. I believe that peace and human happiness are more important than the tragic options of the heroes of Antiquity. After turning our backs on fantasies that could never be achieved, we have finally succeeded in talking to each other face to face around the same table. After all, the art of negotiation and compromise is one of the great qualities of the people of our region. Isn't it better to use this art than to make war?

Today, at a time when the peace process is under way, something paradoxical between Israelis and Palestinians is emerging—the mistrust that stems from love. Mistrust is the culmination of the long struggle that has pitted our two peoples against one another because they both love this blood- and tear-soaked land. Several decades of bitterness and frustration have only made them more impatient and heightened the temptation to say no. And so we must make a tremendous effort to clarify things in order to sow the seeds of mutual acceptance and sharing in the minds of everyone. The hostility that arises between adversaries during the struggle can be transformed into mutual respect insofar as experience has taught them more about each other and as long as the outcome safeguards the dignity of all. ■

EDITORIAL

THE interview which opens this issue has a symbolic importance that will be evident to all our readers. Amos Oz is a great Israeli novelist, deservedly taking his place among the leading artists, scientists and writers from every corner of the globe whom the *UNESCO Courier* welcomes to its pages month by month. He has also been in the forefront of efforts to achieve peace between Israelis and Palestinians, peace that has so suddenly, so unexpectedly, ceased to be a dream and become an ongoing political and economic process. Amos Oz has been in the vanguard of those who have, at great risk to themselves, reconnoitred the no-man's-land where dream and reality for so long tried in vain to meet.

This issue also carries a dossier on UNESCO's General Conference. The session that opened on 25 October, as well as considering the Organization's programme and budget for the next two years, will also see the election for the post of Director-General. We have taken the opportunity to focus on some of the issues and projects that are being discussed during the Conference and to present Federico Mayor's views on this turning point in the life of UNESCO.

Last but not least, the main theme of the issue is the origin of numbers and the numeration systems that are among the great intellectual inventions of humanity. The articles have been written by specialists who were asked to explain in terms accessible to those of us who may not be of a mathematical turn of mind some of the latest findings of scientific research in their field. We hope you will agree with us that they have successfully risen to the challenge. ■

BAHGAT ELNADI AND ADEL RIFAAT

The origin of numbers

The story of a great intellectual adventure

by Tony Lévy

Above, detail of an ancient Egyptian painted low-relief depicting a table for funerary gifts (2700 B.C.). On it several numbers are written in hieroglyphic script (the hieroglyph for 1000 appears four times, bottom right).

IT is generally accepted that some animal species are capable of perceiving quantitative differences, such as a chick missing from the brood or a more or less abundant food supply. The human infant also shows a kind of quantitative perception in relation to familiar objects long before it is able to speak. The development of language and the use of words widen and refine this quantitative perception, so that some cultures have invented names for vast multiplicities such as the stars in the sky or the sand on the seashore, and have even attempted to quantify infinity.

Counting and recounting

Of all the powers conferred by speech, that of naming numbers certainly seems to be among the oldest. After all, "numbering" means organizing and putting in order the real world and our ideas about it. This is apparent in the idiom of different languages.

English	eighteen	8-10
French	dix-huit	10-8
German	acht-zehn	8-10
Ancient Greek	okto-kai-deka	8 and 10
Modern Greek	deka-okto	10-8
Latin	decem et octo	10 and 8
Latin	duo-de-viginti	2 from 20
Lithuanian	ashtuno-lika	8 left over (from 10)
Breton	tri-ouch	3-6
Welsh	deu-naw	2-9
Mexican	caxtulli-om-mey	15 and 3
Finnish	kah-deksan-toista	2 (from) 10 (in the) second (ten)

(from K. Menninger, *Number Words and Number Symbols*)

Different ways of forming the number 18.

In some European languages, for example, there is a strong similarity or even an overlapping between words meaning "count" and words meaning "tell": *compter/raconter* in French, *contare/raccontare* in Italian, *contar/contar* in Spanish and Portuguese, and *zählen/erzählen* in German. In modern English the word *tale* denotes a story, but the word *teller* can be used to designate a bank cashier as well as someone who tells a story. So it is not surprising that this similarity is found in older Indo-European languages. Etymologically, the Sanskrit term for number, *sankhya,* denotes a way of saying things. The Greek word *logos,* denoting both reckoning and also word or speech, derives these different meanings from the old sense of the verb *lego,* to collect, choose, gather, and hence to reckon, count, enumerate, and then to recount or say. Similarly the Greek word *arithmos* means both number in the arithmetical sense and also adjustment or disposition. This ambivalence later shifted to the Latin *numerus* and its derivatives. The adjective *numerosus* means both numerous and harmonious.

Moving away from the Indo-European languages, we find a similar situation in two Semitic languages, Arabic and Hebrew. In Arabic the word for account is *hisab,* from the triliteral root h.s.b. The verb "to count" is *hasaba,* which with one vowel change becomes *hasiba,* to imagine, believe. Likewise with Hebrew, which from one root, s.p.r., constructs the words for book, *sepher;* number, *mispar;* and story, *sippur.*

■ Words and numbers

Whatever numerical facility a given language may have developed, the names it uses for numbers seem to go back to a very early period in the history of that language and have, moreover, remained amazingly stable through the ages. They are reminders of human strivings since time immemorial to bestow names on the diversity of the real world, and occasionally they provide us with a glimpse of the process that preceded and underlay the naming of the various orders of quantity.

One example, that of the number 9, illustrates the interest—as well as the difficulty—of historical analysis. In many Indo-European languages the word for this number is strikingly close to the adjective conveying the idea of newness: Latin *novem/novus,* French *neuf/neuf,* English nine/new, German *neun/neu,* Sanskrit *nava/navas.* Combining the disciplines of the linguist and the historian, one is tempted to explain the phenomenon as follows: at the dawn of counting, the number 9 was perceived as a "new" level after 8. The word for 8 (*octo, huit,* eight, *acht, ashta* in the five languages cited above) could be derived in its turn from a grammatical dual of the word for 4 (*quattuor, quatre,* four, *vier, tchatvara*). In the light of many other linguistic and cultural phenomena it turns out that the number 4 really does represent a new stage in our perception of numbers. We can easily discern one, two, three or four objects without needing to count them, but from five

A runic calendar (Finland, mid-16th century). Runic writing, using an alphabet of characters known as runes, was used by the Germanic peoples of northern Europe between the 3rd and 17th centuries.

A Phoenician inscription on gold leaf in honour of the goddess Astarte (early 5th century B.C.).

onwards we have to count them before we can say how many there are.

This is an attractive hypothesis, although in such a field it is impossible to be dogmatic. If we pursue our linguistic investigations a little further, we can even find new arguments to support it. Most Semitic languages use phonetically related terms to denote the number 9: Akkadian uses *tishu*, Hebrew *tesha'*, Syriac *tscha'*, Arabic *tis'un*, and Ethiopian *tes'u*. Arabic grammar indicates that the word *tis'un* is derived from the verbal root *wasa'a*, "to be or become wide". Thus it is possible that the notion of "newness" observed in the Indo-European languages recurs in the Semitic ones.

■ *Ordering, combining and counting*

Any number system, however elementary, presupposes the adoption of a small number of symbols—words, pictograms or graphic signs—structured according to two principles. A principle of order or arrangement distinguishes the first symbol (one) from the second (two) and if necessary from the third (three) etc., and a principle of grouping or combining interrupts the series of distinct individual symbols by introducing a symbol of a higher order of magnitude which is then combined with the previous symbol to continue the system. Thus "one, two, three. . . , **ten,** ten-one, ten-two. . . , ten-ten or a **hundred,** a hundred and one, a hundred and two. . ." is called a base-10 system or decimal system.

But other bases have been or still are used: base two (the binary system), five (quinary), twenty (vigesimal) and sixty (sexagesimal). It seems likely that the bases 5, 10 and 20 were originally chosen because of their relationship to characteristics of the human body, and traces of this remain in some oral counting systems. In Api, the spoken language of the New Hebrides, the word *luna* denotes a hand, and also the number 5; the number 2 is *lua*, and 10 is of course *lualuna*—literally, two hands.

The variety of the rules governing the formation of the names of numbers is a striking instance of human cultural and linguistic diversity. The table on the opposite page illustrates how the number eighteen is formed in various languages.

We must recognize, however, that little is known about the methods of reckoning used in very ancient times. Certainly the numbers for which words already existed had to be represented symbolically. In addition to verbal numeration manual gestures were used (counting on the fingers) or physical devices such as an abacus, a counting frame, a sand-table or a knotted cord. To the historian, this representational numeration seems in some cases to foreshadow certain forms of written numeration.

■ *Counting systems, writing systems and alphabets*

The advent of writing resulted in a fantastic growth in numerical capacity. Written counting systems or numerations may be divided into

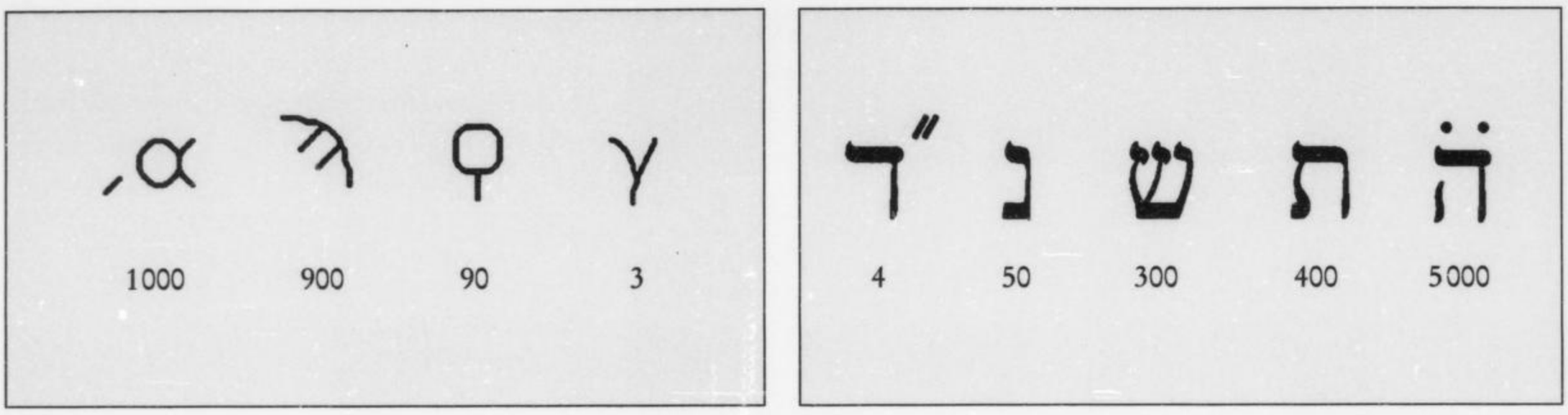


Figure 1. Alphabetical number systems
1993 in Greek alphabetical numeration (left)
5754 in Hebrew alphabetical numeration (right)

two main types: additive numeration, in which a number is produced by directly adding together the numerical value of its component symbols, as in Ancient Egyptian hieroglyphic numeration and in Roman numerals, and positional or place-value numeration, in which the value of a symbol (units, tens, hundreds, etc.) is determined by the position it occupies. Thus 1034 (written from the left to the right, "one-zero-three-four") represents one (thousand) plus zero (hundreds) plus three (tens) plus four (units). This system, which requires the use of a zero (a blank space or a graphic sign) appeared historically only in four civilizations with written languages: in Mesopotamia, in China, in ancient India and in the Maya civilization of central America.

Though writing first appeared in Sumer during the fourth millennium B.C., alphabetical scripts were doubtless invented in the middle of the second. The best-known and most influential script was that developed by a trading and seafaring people, the Phoenicians, who spoke a Semitic language. It was adopted or adapted by other languages in the same group (Hebrew, Aramaic and later Arabic), as well as by other languages less closely related to Phoenician. The Phoenician alphabet only transcribed consonants, of which there were 22. The Greeks later added vowels to it. The Latin alphabets, descended directly from the Greek, retain the order of the Phoenician alphabet almost unchanged.

Mastery of this extraordinary tool led to the development of a number of counting systems including the ancient Hebrew system, the so-called "learned" Greek counting system, and the Arabic counting system known as *hisab al-jummal* or *hisab abjadi*. These were alphabetical additive numerations, whose principle is extremely simple provided the user knows the order and numerical value of the letters of the alphabet. The first nine letters correspond to the nine digits (1, 2 , 3, . . ., 9), and the next nine to the nine tens (10, 20, 30 . . . 90). The remaining letters are used to denote the hundreds. Thus alphabetical numbers are written in descending order of numerical value of their constituent letters, in the direction of the script (**figure 1**).

Since the alphabet comprises only a small number of different signs (22 in Hebrew, 28 in Arabic and 27 in Greek), this counting system initially only allowed the representation of numbers below 10,000. Various expedients were available for going further, but it became difficult to handle large numbers. Consequently scholars, particularly astronomers, had to adopt the far more efficient Babylonian sexagesimal positional number system and adapt it to their script. In principle this numeration requires 59 different symbols plus a sign for zero. These "sexagesimal digits" would often be expressed in alphabetical numeration, thus combining the power of positional notation with the convenience of alphabetical notation.

A legacy from India

The decimal positional numeration system with a zero, as developed in India, gradually came to supersede other written systems and is now in virtually universal use. It spread slowly, however, and in a complex fashion.

China, for instance, acquired a decimal positional system of its own quite early on, independently of the Indian one, but one which did not use a zero. It may even be supposed that the Chinese could have designed a system like the Indian positional system on their own. But the introduction of the zero into the Chinese positional notation seems to have been of Indian origin (**figure 2**).

Nowadays schoolchildren in the West learn to count with "Arabic numbers": but what

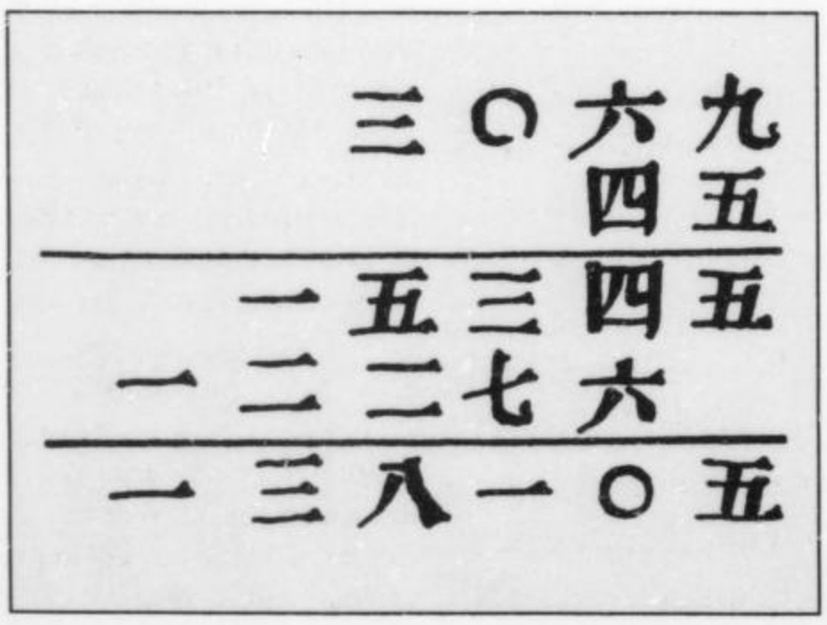


Figure 2. Use of the zero in ancient China
Multiplication of 3069 by 45 (from a 14th-century Chinese mathematical treatise).

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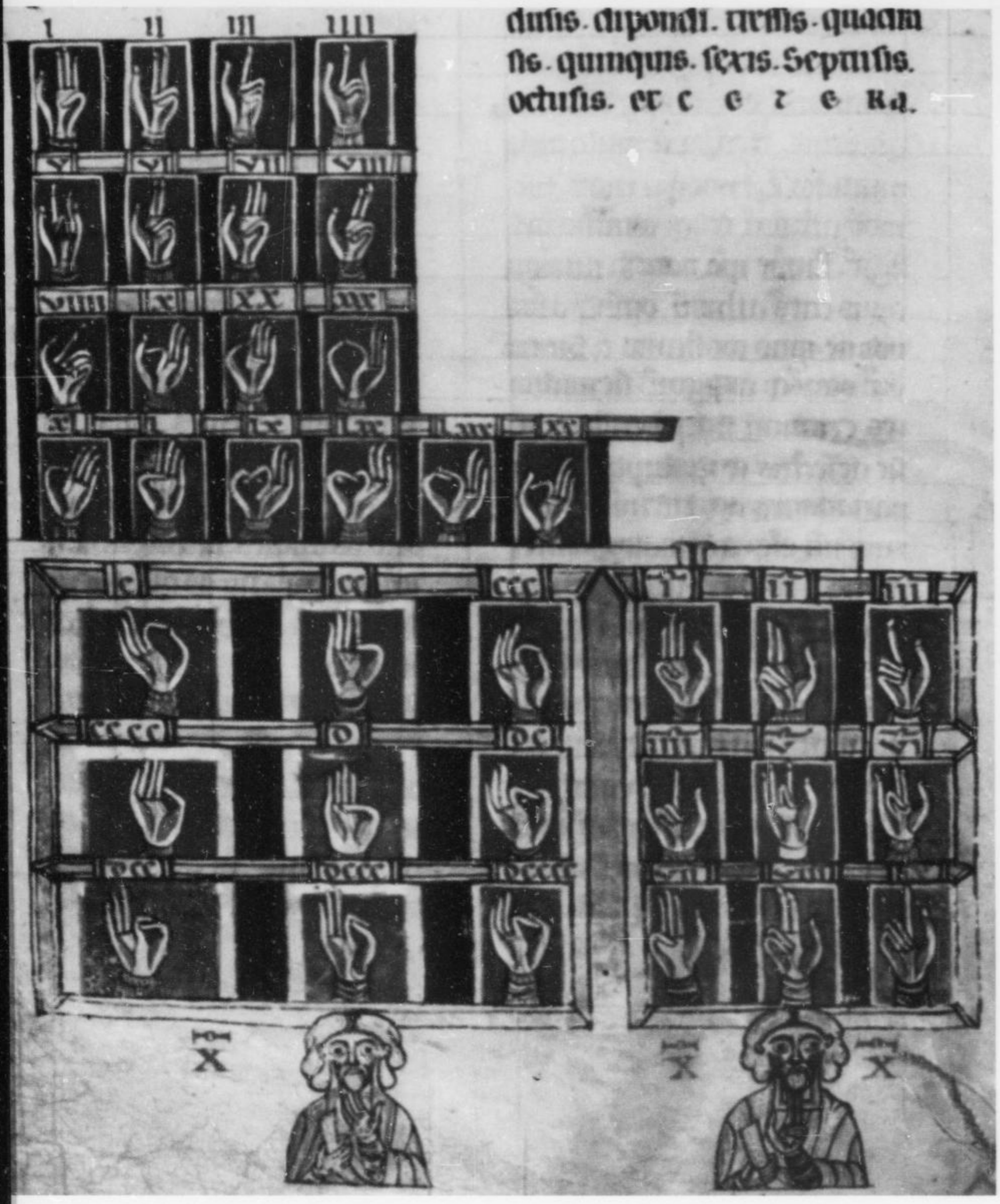

dinis. diponit. tertis. quadra
gis. quinquis. sexis. Septuagis.
octuagis. et c e t e ra.

A system for counting on the fingers is shown in this illustration from a 13th-century Spanish manuscript.

exactly are they? We owe our knowledge of the principles of Indian arithmetic to Arab scholars of the eighth century. In about 774 A.D. an Indian scholar passing through Baghdad made known a Sanskrit book on astronomy which adopted the principles of "Indian arithmetic" (*hisab al-hind*), and al-Fazzari's Arabic translation of this book represented the first stage in the history of "Indian arithmetic" in the Muslim-Arab empire. The Arabic word *sifr,* "emptiness", is a translation of the Sanskrit *sunya.* It was chosen in the ninth century to represent zero. *Sifr* gave rise to the Latin *cifra* in the thirteenth century, the French *chiffre* in the fourteenth century and the German *Ziffer* in the fifteenth century. It is also the forebear of the English *cipher.* By a parallel development *sifr* gave rise to the Latin *zefirum* in the thirteenth century, the Italian *zefiro/zevero* in the fifteenth, and finally the word *zero.* Western terminology is unquestionably Hindu-Arabic.

We must, however, distinguish between the spread of knowledge about the principles of Indian numeration and the development of the graphic signs used for its notation. The relationship between the written forms recorded from India and those that appeared in the Arab world from the ninth century onwards is not clear. Moreover there is a difference between eastern and western Arabic numerals. While the principles of Indian numeration spread in Latin in the medieval West in the twelfth century, the figures we call "Hindu-Arabic" spread through intermediaries that have not all been identified, sometimes borrowing from earlier Roman or Visigothic forms in Spain. ■

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Sumerian sums

by James Ritter

The origins of a positional system of numbering in ancient Mesopotamia

Bronze head of king Sargon, founder of the Akkadian dynasty (2400-2200 B.C.).

WHEN, during the last one hundred years, scholars began to understand the written numerical system of the ancient Mesopotamian world in the last two millennia before our era, they discovered that it had two highly distinctive features. First of all the Mesopotamians used a unique system with the base of 60. Secondly, they differed from the other known ancient peoples by using a system of place notation, as we do, to express their written numbers. All kinds of explanations for the existence of these two strange features were put forward. Some thought they might have had something to do with the Sumerian calendar; others that they were due to the convenience of the number 60, so rich in divisors; others still that they were the result of a psychological peculiarity of the Sumerian people. We now know, however, that the answer lies in the genesis and development of writing in Mesopotamia, or more precisely in the relation between bookkeeping and writing—the fact that the original purpose of writing *was* bookkeeping—and was the outcome of a process lasting a thousand years.

Since the Mesopotamians used artefacts made of clay, a virtually indestructible medium, to keep their accounts, we can follow the development of writing in Mesopotamia (and in neighbouring Susa) at the end of the fourth and the beginning of the third millennium. Initially bookkeeping was done using hollow clay balls which contained small tokens of varying sizes and shapes and whose surfaces bore the impressions of cylinder seals. The form and size of the tokens represent the object and/or the counting or measuring unit employed. The seal impressions on the outside indicate the owner or contracting parties, or the controlling official.

During the next several hundred years this system evolved. First, the tokens were impressed on the surface of the ball before being enclosed; next, the tokens themselves were abandoned, and only their impression on the surface of the now flattened ball or tablet was retained; finally, a reed was used instead of a token to create the surface marks.

By around 3200 B.C., a writing system had developed that consisted of a repertory of some 30 numeric and 800 non-numeric signs, used to designate the items counted and geographical and official names.

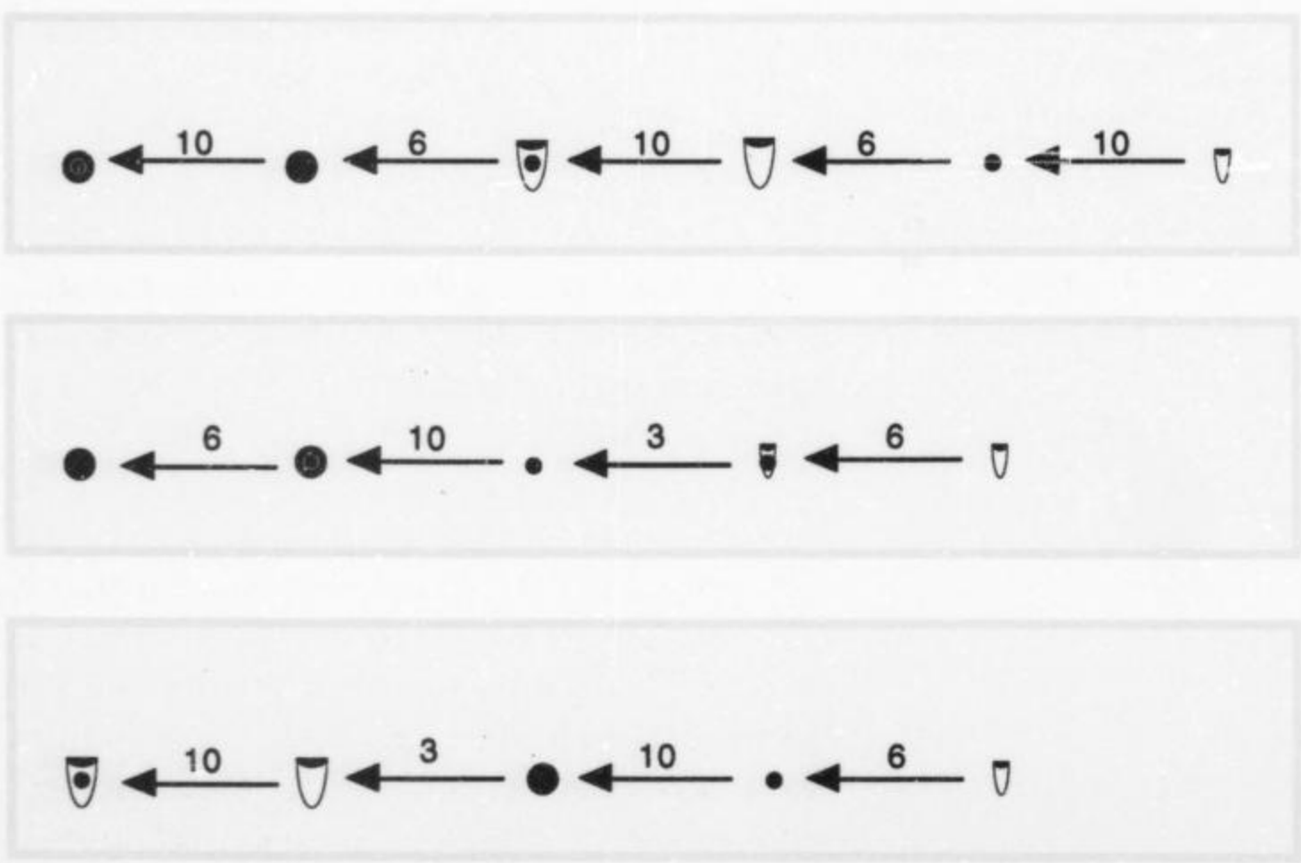
A dozen different counting systems

A large number of different ways of counting were used in Mesopotamia during this period (3200-2800). These systems included one for counting discrete objects and lengths, one for measuring surfaces, another for determining volumes of grain (subdivided into a number of different subsystems for different kinds of grain!), yet another for measurements of time. There were probably close to a dozen of these metrological systems. Three of them are shown in **figure 1**.

To express a number in any of these systems an additive technique was used; in other words a number sign was used as many times as there were units represented by that sign. This can be seen in **figure 2**, a text showing the number of sheep in a flock.

But despite the wealth of systems, the repertory of numeric signs was small. In fact, all the signs were essentially built up from only four different marks of the reed: a large and small circle, and a large and small notch (**figure 3**). Furthermore these signs were used only in cer-

Figure 1. Three ways of counting
The arrows point from the lower value to the higher value unit. The number on top of the arrow indicates how many of the lower value unit make up the higher value unit, e.g. 1 small circle = 6 small notches in System Š, 10 small notches in System S, and 18 small notches in system G.
System S (sexagesimal—for counting discrete objects and measuring lengths)
System G (surface measures)
System Š (capacity measures)



Mesopotamian clay tablet used for bookkeeping (c. 3000 B.C.).

tain combinations: either separately (four signs) or combined in the form circle + notch of the same size or circle + circle of two different sizes—this yields seven signs in all.

These few signs were thus used differently in different systems: the small circle is worth 10 small notches in the system used for discrete measurements (system S), 6 small notches in that used for measuring capacity (system Š), and 18 in that used for surface measurements (system G). The "numeric signs", then, have no intrinsic value, only that lent by the system in which they appear. Furthermore the ratios between successive signs—their "relative values"—vary from one system to another. Thus there is no general idea of number, only ways of counting.

For the 500 years starting around 3200 B.C., the range of texts produced in Mesopotamia is very restricted. They are overwhelmingly accounts, consisting of numbers drawn from the various metrological systems with the addition of signs representing the objects thus counted, but also geographical names and official titles. There is also a handful of school texts, lists of the signs and words, both numeric and non-numeric, that the young apprentice scribe had to master in acquiring his craft. The principal role of scribal training was the training of a corps of bookkeepers. The idea that writing can be diverted from bookkeeping, and used to record a spoken language—the role of writing which seems so natural to us—was slow in developing, taking over 500 years.

A dual evolution

Some time around 2600 B.C., the developing city-states that constituted ancient Sumer achieved sufficient size and wealth for writing, hitherto found at only a few sites, to become common all over southern Mesopotamia.

One of the reforms carried out during this period of consolidation was that of the metrological systems. The number of such systems was reduced from a dozen to a mere handful, one for discrete and length measures, one for areas and one for capacity. To these three was added a new system, to measure weight. Rather than invent new numbers to indicate values in this system, it was decided to use the numbers from the system used to measure discrete objects, following them with the names of the units of weight. This system proved so practical that the names of weight units and their relative values were taken over into the surface metrological system, and used there to express small areas.

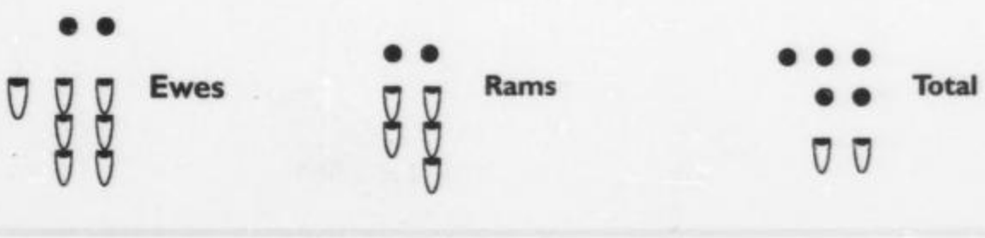


Figure 2. Counting sheep
Expianation:
2 x 10 + 7 x 1 = 27 ewes and
2 x 10 + 5 x 1 = 25 rams, a total of 5 x 10 + 2 x 1 = 52 sheep.

Figure 3

This idea—the naming of units—was one of the two major innovations of this period, and was not restricted to the weight system and its extensions. Even the larger units of length or volume now began to carry names. The scribe wrote a number-sign + "*bur*" for surface measurements, and a number-sign + "*nindan*" for lengths. Of course once the names of units are written, it becomes possible to see immediately which form of measurement is being made. The scribes of Mesopotamia were to make increasing use of this new method.

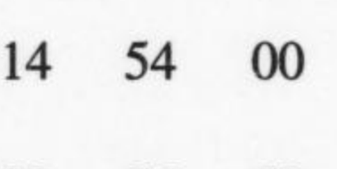
The other important change in this period relates to the writing of numbers. In the case of areas, the sign [A] takes the place of the older [B] (**figure 4**), the outer of the two concentric circles being replaced by four crossed "cuneiform" strokes (from Latin *cuneus*, "nail" or "wedge"). This is just one example of the growing "cuneiformization" of the writing system—including number signs—that is typical of this period. To an increasing degree, the curvilinear, incised lines of the older, semi-pictographic form of the script, difficult to trace in clay, were replaced by the faster and simpler method of impression of the reed. This evolution of the writing system, already timidly apparent during the previous period, spread rapidly during this

Figure 4

A B

C D

Figure 5



E F

Figure 6

61 2

period, and virtually squeezed out the older, rounded numbers by the end of the millennium.

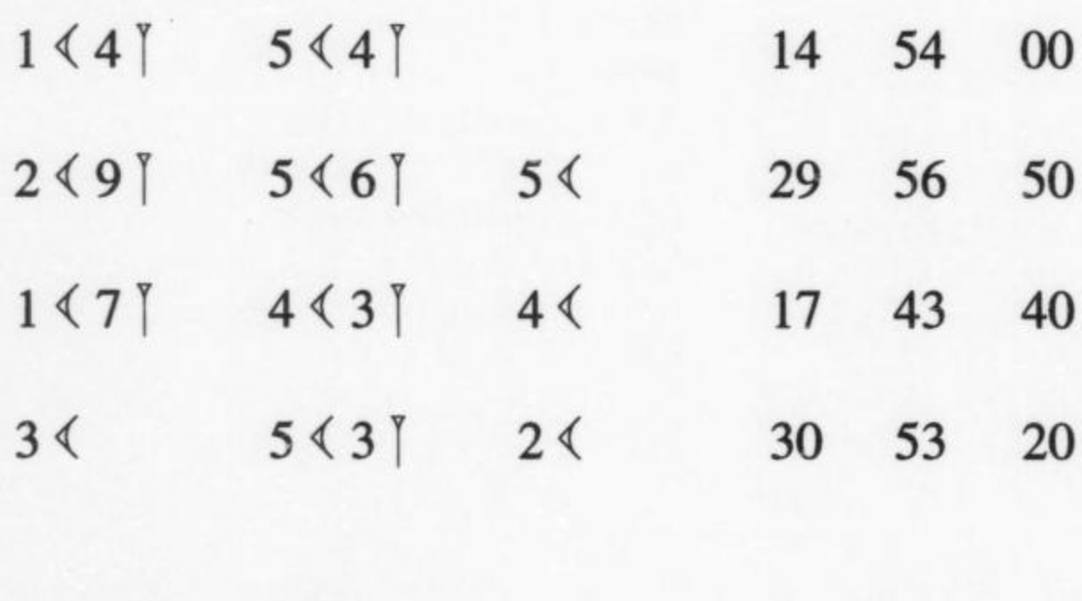
■ *Speedy scribes*

The period from 2350 to 2200 B.C. saw the building of the first major empire in Mesopotamia, that of the Akkadians, who spoke a Semitic language. Two of the innovations introduced by the new centralized administration of the Akkadian empire, which at the height of its power stretched from the Gulf to Syria and Lebanon, also played a crucial role in metrology and writing.

The systems of units inherited from the previous period were rationalized and adjusted so that simple correspondences would exist among them. Although the complexity of the old ways of counting was never totally banished, the ratios of units tended to stabilize around fixed values. Furthermore the system of numbers used for measuring discrete objects now began to be widely used for other kinds of measurements, coupled with the use of names for different units.

At the same time the older numbers such as [C] and [D] were replaced by [E] and [F] (**figure 5**). The long march of cuneiformization was still under way. These changes, dictated by the need for efficiency in performing the growing number of bureaucratic tasks in the Akkadian empire, have a double edge. Certainly it is simpler and faster to write the new cuneiform numbers than the old rounded numbers, but the speed is purchased at a price. The difference between the small unit and the one sixty times larger was quite small, a question of a slightly larger "head" to the simple vertical stroke. The

Figure 7. The significant detail



1 4	5 4		14	54	00
2 9	5 6	5	29	56	50
1 7	4 3	4	17	43	40
3	5 3	2	30	53	20

= 10 = 1

Total: 1 1/2 **mana** 3 1/2 **gín** minus 7 **še** silver

Column 1 (rightmost): 0 + 50 + 40 + 20 = 60 + 50 — put down 50 and carry 1
Column 2: 54 + 56 + 43 + 53 + 1 (carried) = 207 = 3 x 60 + 27 —put down 27 and carry 3
Column 3: 14 + 29 + 17 + 30 + 3 (carried) = 93 = 60 + 33 —put down 33 and carry 1
Total: 1 33 27 50

Since 1 **mana** = 60 gín = 1 00 **gín** (base 60) and 1 **še** = 1/180) **gín** = 0;00 20 **gín** (base 60):

1 33 27 50 = 1 33; 27 50 **gín** = 1 **mana** +33 **gín** + 83 **še** (rounded off, 83 se = 0; 27 40 **gín)** or, written more traditionally, 1 1/2 **mana** (= 1 **mana** 30 **gín**) + 3 1/2g (= 3 **gín** 90 **še**) — 7 **še.**

Figure 8. The sexagesimal system

In our decimal, positional system, we use the nine digits 1, 2, 3,....,9 plus 0; the value of a digit in a number is determined by its position in that number, each place representing a power of ten. Thus, in the number 161, the rightmost 1 is worth one unit, while the leftmost 1 is worth one hundred and the 6 is worth six tens, i.e.:

161 = 100 + 60 + 1 = 1 x 100 + 6 x 10 + 1 x 1 = 1 x 10^2 + 6 x 10^1 + 1x 10^0.

In the sexagesimal, base sixty system, there are 59 digits (zero is represented by a blank space). Thus the number written by putting side by side the three cuneiform digits representing 29 56 50 can be translated into our decimal system as:

29 x 60^2 + 56 x 60^1 + 50 x 60^0 = 29 x 3600 + 56 x 60 + 50 x 1 = 104400 + 3360 + 50 = 107810
This is of course exactly the system we use for reading time:
29 hours 56 minutes 50 seconds = 29 x 3600 + 56 x 60 + 50 = 107810 seconds.

Figure 9. The Mesopotamian "zero"

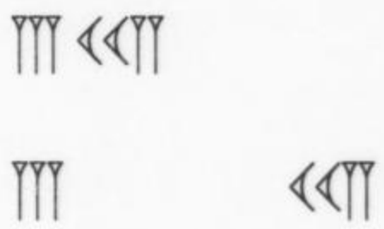
There are two main uses of the zero in our modern numerical notation:
—as a number, for example one can add 0 to 5 with the result 5;
—as a place-holder in a number. The number 5020 indicates that there are 5 thousands, no hundreds, 2 tens and no ones.

The Mesopotamians never created the concept of a number zero. They did need to indicate empty places in a number, however, and for this they used two different methods.

The first method, used from the time of the invention of a positional notation at the end of the third millennium to the end of the first millennium, was to a leave a blank in the writing of a number to indicate that there were no units of that particular power of 60. For example, the number 3 22 (3 sixties and 22 ones) was written as shown in example Y (above), while 3 00 22 (3-thousand-six-hundreds, no sixties and 22 ones) was written as shown in example Y (below).

Very late in the life of the Mesopotamian civilization, in the Seleucid period (from the end of the fourth century B.C.), one finds another method, using a written zero place-holder, especially in astronomical texts. Thus the sexagesimal number 3 00 22 was noted at this period as shown in example Z.

Y



Z

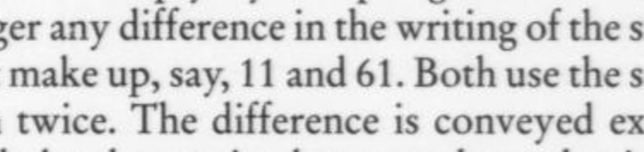
difficulty of distinguishing between the two numbers 61 and 2, for example (**figure 6**), when hastily written—and read—poses a critical problem of ambiguity. The resolution of this problem by the Mesopotamian scribes, probably during the Akkadian period or in that just following, was precisely to turn this ambiguity to good use by creating a positional system.

The birth of positional notation

After the period of disruption that followed the end of the Akkadian empire, a newly centralized state was founded in Mesopotamia; the city-state of Ur successfully established a new empire, which we call the Third Dynasty of Ur, or Ur III.

A single text (**figure 7**) among more than 100,000 from this period, has left us a trace of the technical and conceptual revolution that took place during the Ur III and the preceding Akkadian epoch. A bookkeeping text dealing with a delivery of silver, it is quite ordinary except for one detail: the scribe has forgotten to erase the mathematical calculations he made in drawing it up. The writing of these calculations shows us that, at least by Ur III times, the full positional system in base 60 was in place. What the scribe has done in the first four lines is to write down the weight of four separate deliveries of silver in positional, sexagesimal notation. In this system, each place represents a power of 60, with the

Figure 10.



numbers in each running from 1 to 59 (**figure 8**). The signs used for writing these 59 numbers are created by using the first two signs of the now totally cuneiformized system for discrete objects: the wedge for the value of 10 and the stroke for 1. A blank space appearing in a number represents the Mesopotamian "zero" (**figure 9**). In the final line the scribe has translated the sum of the four entries into the traditional system for measuring weight.

As can be seen from this example, the ambiguity mentioned above between 61 and 2 is resolved simply by accepting it. There is no longer any difference in the writing of the signs that make up, say, 11 and 61. Both use the same sign twice. The difference is conveyed exclusively by the spacing between them, that is, by giving a significance to the relative *position* of the two signs (**figure 10**). The positional system of Mesopotamian mathematics was born. And this system was sexagesimal; the Mesopotamians had chosen a sexagesimal system from the various systems at their disposal.

So it was neither a psychological peculiarity of the Sumerian and Akkadian peoples, nor mystical and religious ritual, nor again complicated mathematical criteria of divisibility which led to the sexagesimal, positional system of Mesopotamia. Rather, pushed by the economic and social needs of an increasingly centralized state operating over a period of a millennium, two simultaneous developments—the increasing reliance on numbers drawn from a single metrological system and the progressive cuneiformization and consequent risk of ambiguity in the writing of numbers—interacted to form the number system that was to be used in Mesopotamia for the following 2,000 years. As we have seen, it was the increasing predominance of one particular metrological system with its particular choice of relative values which gave birth to a sixty-based number system, and it was the cuneiformization of writing that was responsible for the creation of a positional notation.

Most important of all was a possibly unlooked-for result of these two developments. The same number-signs could be—and were—used to write the numbers involved in calculations in all the metrological systems. The new system was not attached to any of the traditional ways of counting; numbers had become free-floating and the detachment of number and measure was complete. The end of the third millennium B.C. saw the birth of the concept of number, abstracted from any particular unit. ■

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The mathsticks of early China

by Du Shi-ran

The ancient Chinese devised an original system of calculating using counting rods

Schoolchildren learn to use the abacus in Nanking (China).

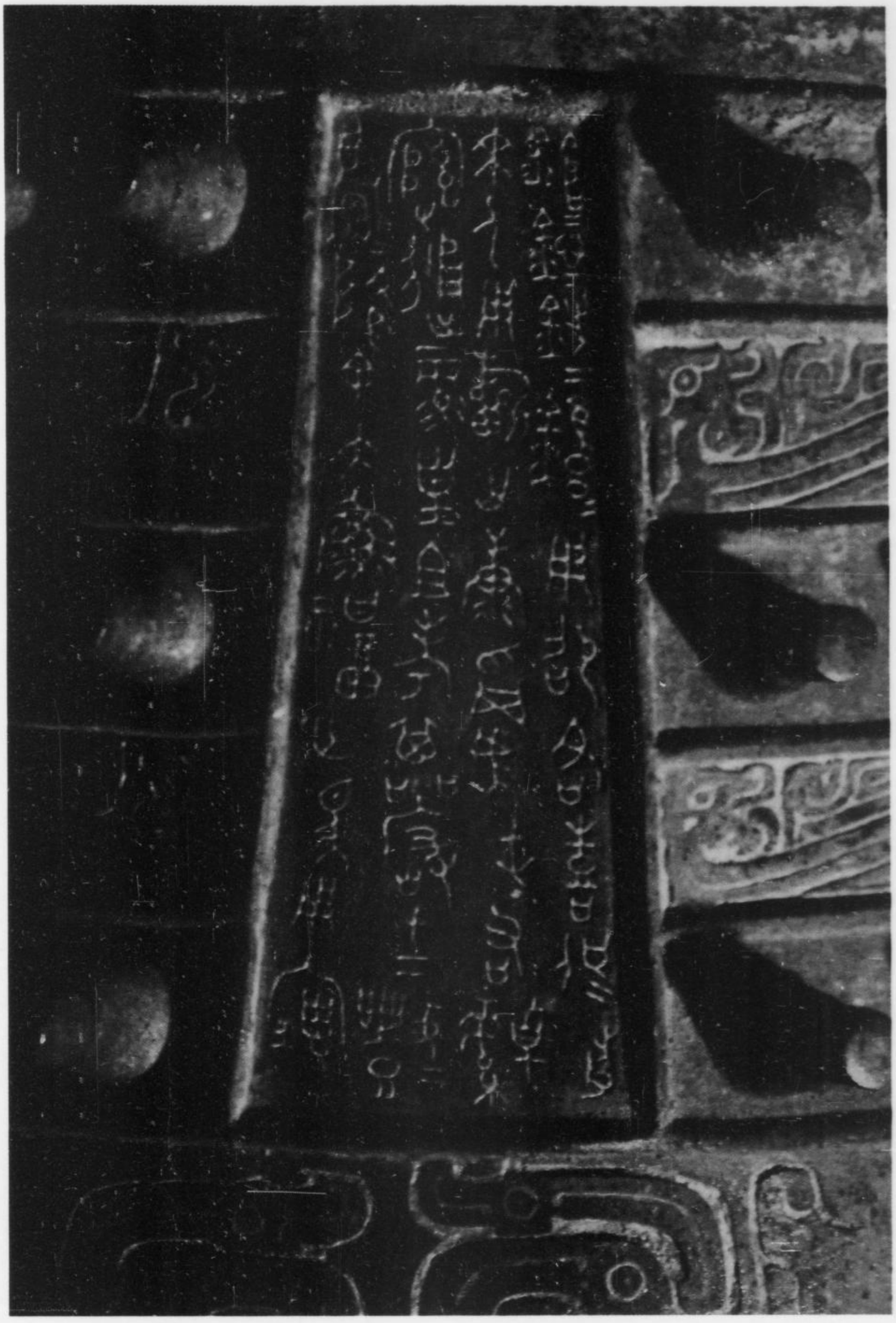
THE origins of numeration in China go back into the dim and distant past and since, as in many other countries, no-one knows precisely how it began, all sorts of legends and myths sprang up. An ancient book called *Shi Ben* ("The Book on Ancestries") tells how the legendary Yellow Emperor, regarded as the first emperor in China's history, ordered his subjects Xi He to observe the sun, Chang Yi to observe the moon . . . and Li Shou to invent arithmetic. The story of Li Shou became widely known, and people imagined that he discovered the concept of numbers by himself.

But to credit the concept of numbers to one man obviously does not accord with the historical facts; such a complex concept could not have been worked out single-handed, even by a genius. It is obvious that numbers gradually evolved throughout the long history of humanity in response to practical requirements.

Certain features in the evolution of Chinese numeration can be inferred from legends and myths, but more important clues can be drawn, and more accurate deductions can be made, from archaeological evidence.

Archaeologists discovered that some earthenware from the 7,000-year-old Yangshao Culture (excavated in Henan and Shanxi Provinces) bore specially inscribed signs and marks. Most of the marks were vertical lines, while others were Z-shaped. These vertical lines are believed to be the very earliest forms of numeration in ancient China.

After tens of thousands of years of primitive civilization, a society with a class structure evolved in China. This was the slave society of the Shang dynasty (circa sixteenth to eleventh centuries B.C.). It is clear from archaeological evidence that this culture was fairly well developed, producing bronze weapons, household utensils and sacrificial vessels. Around the fourteenth century B.C., the Shang Dynasty moved



Detail of bronze bell showing inscriptions, Western Zhou period (8th century B.C.).

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its capital to the neighbourhood of the present-day Xiaotun, near Anyang in Henan province. Culture and the economy took a further step forward, and a form of calendar appeared.

■ *The oracle bone script*

In the course of the present century, a large collection of plastrons—the ventral part of tortoiseshells—and animal bones inscribed with characters have been excavated in the same area. Research has shown that the nobles of the Shang period worshipped the spirits of their ancestors. In their prayers they put questions to these spirits, inscribing the questions, the answers, and sometimes the subsequent verifications on the plastrons and on animal bones. The characters used in the inscriptions are generally known as "oracle bone script," and this is the earliest form of Chinese writing so far discovered, although isolated symbols have been found on Yangshao pottery.

Among the 5,000 characters used by the Shang people on the excavated oracle bones are the earliest known Chinese numerals. The oracle

bones recorded how many prisoners were taken in war or how many of the enemy were killed, how many birds and animals the hunters caught and how many domestic animals were sacrificed to the spirits. Days were also numbered. Here are some examples:

"On the eighth day, namely the day of Xinhai, two thousand six hundred and fifty-six men were killed while crossing spears."

"Captured ten and six men."

"Ten dogs and five dogs."

"Ten cattle and five."

"Deer fifty and six."

"Five hundred four tens and seven days."

The largest number inscribed on the oracle bones is 30,000 and the smallest is one. Units, tens, hundreds, thousands and ten thousands each have a specific character to represent them (**figure 1**).

Ancient inscriptions on bronze have also been found, in what is known as "bell vessel script" or "bronze script," and research shows that most of them date from the Zhou period (around the eleventh century to 221 B.C.). The numerals were written in a similar way to those on the oracle bones. In the bronze script, however, compound words are written quite differently from the oracle bone script. The modern Chinese *you*, meaning "and" is used to separate units, tens, hundreds and thousands. The number 659, for instance, is written as 600 and 50 and 9.

In the Han Dynasty (206 B.C. to 220 A.D.) the character used for separation in recording (large) numbers was dropped and compound numerals also disappeared. The shape of character then used is almost exactly the same as in present-day Chinese.

To show how the characters have evolved, **figure 2** compares the characters for one to ten in oracle bone script, in bronze script, in the Han Dynasty script, in present-day Chinese characters and in modern Western (or Hindu-Arabic) numerals.

■ Counting rods

So far we have discussed decimal notation, but in ancient China calculations did not directly involve the manipulation of numerals. The device used for calculations by the ancient Chinese was the counting rod.

The counting rods were small bamboo sticks known as *chou* which Chinese mathematicians arranged into different configurations to represent numbers before performing calculations with them. This was known as "*chou suan*" (calculating with *chou*).

In August 1971, more than thirty rods dating back to the time of Emperor Xuan Di (73-49 B.C.) of the Western Han Dynasty were found in Qianyang County in Shanxi Province. Their length and width conform to the descriptions in

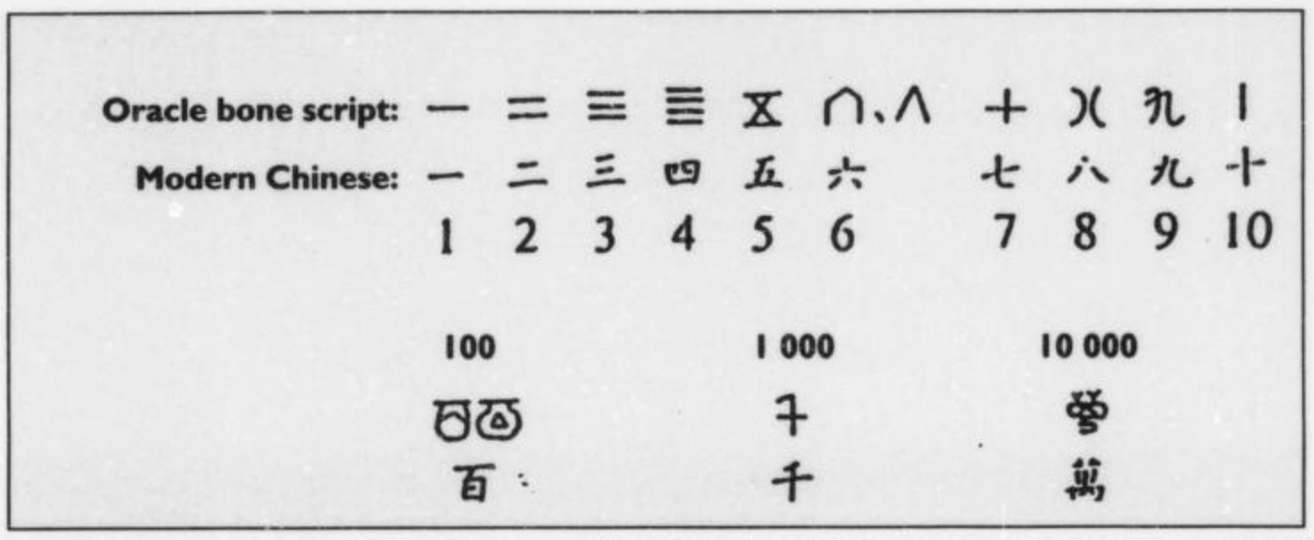


Figure 1. Two ways of writing numbers

the *History of the Han Dynasty*, with the difference that the Shanxi rods are made of bone. A bundle of rods was unearthed in 1975 in Han tomb No. 168 at Fenghuangshan in Jiangling, Hubei Province. These are made of bamboo, but are a little longer than the Shanxi rods. They date from the reign of the Emperor Wen Di (179-157 B.C.). In 1978, a quantity of earthenware with rod signs, dating from the Warring States period (473-221 B.C.) of Eastern Zhou, was found in Dengfeng County, Henan province.

No reliable evidence has yet been found to determine when counting rods began to be used, but it is plausible that people were quite familiar with this technique by no later than the Warring States period. Texts relating to that period which have survived to the present day use the ideograms "*chou*" and "*suan*".

To represent numbers, counting rods could be used either vertically or horizontally, as shown in **figure 3**.

The rods are arranged in accordance with a decimal place-value system, like the present Western system. For units the vertical form is used, for tens the horizontal form, for hundreds the vertical form, for thousands the horizontal form, and so on. A blank space is used for zero.

A number could thus be represented by digits arranged in vertical and horizontal forms alternately, working from right to left in the usual order of units, tens, hundreds, thousands, ten thousands, etc. This method of recording numbers is explained in "Master Sun's Mathematical Manual" (*Sunzi Suanjing*, circa fifth century A.D.) and in Xiahou Yang's "Mathematical Manual" (*Xiahou Yang Suanjing*, circa eighth century A.D.). Master Sun says:

Clay statuette of a horseman, Han period (late 3rd century A.D.).

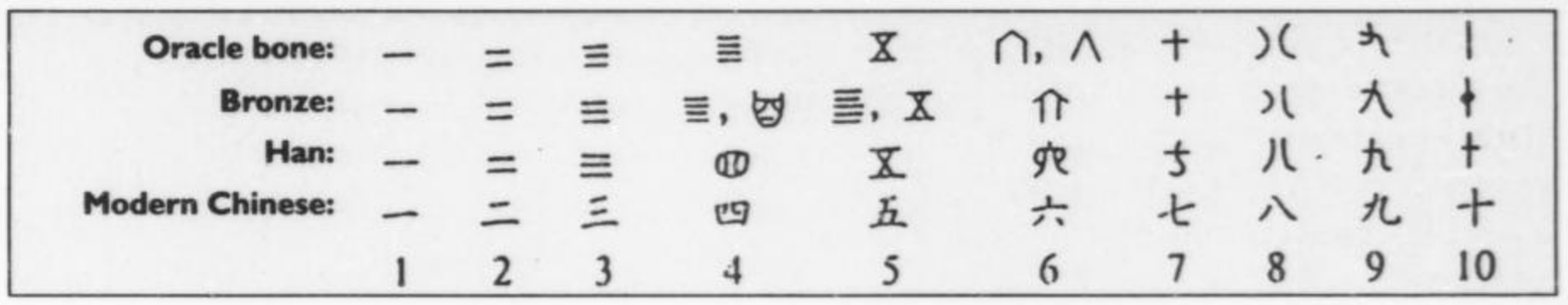


Figure 2

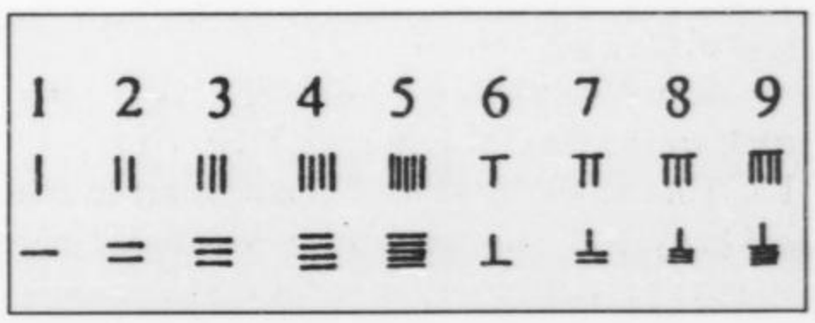
"Units are vertical, tens are horizontal,
Hundreds stand, thousands lie down;
Thus thousands and tens look the same,
Ten thousands and hundreds look alike".
Xiahou Yang's "Mathematical Manual" says:
"Units stand vertical, tens are horizontal,
Hundreds stand, thousands lie down.
Thousands and tens look the same,
Ten thousands and hundreds look alike.
Once bigger than six,
Five is on top;
Six does not accumulate,
Five does not stand alone".

The last four lines mean that for digits equal to or greater than six, the units from one to four are used and a single counting rod standing for five rods is placed on top of them. This is just the same as in the Chinese abacus, where each bead above the crossbar stands for five beads below. The digit six is not represented by piling up counting rods. "Five does not stand alone" means that the digit five must not itself follow the method described above, in which one counting rod is used to represent five. This is to avoid confusion with the representation of the tens, thousands and so forth.

Written language in ancient China was arranged in columns reading from top to bottom and right to left, but when using counting rods to record numbers, the characters were arranged from left to right as in the present way of recording numbers in both East and West.

The decimal place-value method of recording numbers appeared in China at some point during the Spring and Autumn period (770-476 B.C.) or the Warring States period (475-221 B.C.). From then on, various arithmetical operations could thus be performed easily and conveniently. ■

Figure 3



The star system

■ *by Berthold Riese* ■

Head of a priest emerging from the mouth of a serpent. Architectural detail in the Mayan Puuc style (7th to 10th centuries) from Uxmal (Yucatán, Mexico).

In their quest to foretell the future, Mayan priests and astronomers entered the realm of pure mathematics

SEVERAL million Indians living in Guatemala, southern Mexico and Belize today still speak one of the thirty or so Mayan languages, including Mam, Quiché, Cakchiquel, Kekchi and Myathan. A well-developed and broadly similar numerical system exists in all of these tongues.

Centuries of colonization and, more importantly, the introduction of the market economy have led to the gradual replacement of vernacular names for numerals by words borrowed from Spanish. Higher numerals have disappeared from general use and today even the primary numbers are being forgotten.

■ Numbers in everyday use

Archaeological excavations have yielded little information on how numerals were used in the economy of pre-Columbian America. We do know, however, that the Mayas' numerical system was initially based on counting on the fingers and toes. In Quiché, for example, the word for the number twenty, *huvinak*, literally means "a whole person". This method of counting is also reflected in the decimal divisions. The word for 11 is *hulahuh* or *hun* (one) plus *lahuh* (ten). These numbers were probably used in much the same way as we use numbers for counting today, with one difference. The Mayan languages use words known as "classifiers" to describe objects being counted, denoting whether they are round, elongated, stackable, solid or liquid food, etc. For example, a Yucatec would not say, "Here is a cigarette", but "Here is one (*hun*) long, cylindrical object (*dzit*) called a cigarette (*chamal*)".

■ Calendars

The conventional solar year

The Mayan calendar was based on the 365-day solar year, which the Mayas had inherited from the earlier civilizations of the Zapotecs (at Monte Alban) and the Olmecs (at La Venta and Tres Zapotes). The length of this calendar year never varied and was divided using the vigesimal system of numeration into eighteen months of twenty days each. The remaining five days were added at the end of the year. Each month had a name, which does not seem to have been related to the seasons or to any particular festivals. Most of them were handed down by tradition and perhaps even borrowed from other languages and cultures. They do not seem to have had any meaning other than their calendar function, not unlike our own months whose original Roman meanings few people know today.

Each day was designated by a number from 0 to 19 which was placed in front of the name of the month, and from 0 to 4 in the case of the final, shorter month. It was therefore possible to identify each day of the year, as in our own calendar. The years followed each other without interruption and there were no leap years.

The diviner's calendar

Guatemala's Quiché, Ixil and Mam Indians still use a traditional 260-day calendar to predict the future. Why 260 days? In interviews with Guatemalan diviners in Chichicastenango and Momstenango, German ethnologist Leonhard Schultze Jena found that the number of days in the year matches the length of human pregnancy. Whatever its origin may be, the vigesimal system made it possible for early Mayan mathematicians to break this 260-day year down into thirteen months of twenty days each. Each calendar day was identified by attaching a number from one to thirteen to one of the twenty names of the vigesimal cycle, which referred to animals, natural forces and tradi-

BERTHOLD RIESE, of Germany, is a specialist in the field of Amerindian civilizations. His work *Maya-Kalender und Astronomie* (The Mayan Calendar and Astronomy) appeared in *Altamerikanistik* (Early American Studies), edited by Ulrich Köhler and published by Dietrich Reimer Verlag, Berlin, 1988.

Carved glyphs and calendar dates on a 7th-century Mayan limestone stele at Palenque (Mexico).

tional or abstract concepts whose meanings are unknown today.

Like the solar calendar, the diviner's calendar is cyclical. The last day of one cycle is automatically followed by the first day of the next and so on.

The calendar round

Permutation of the 260-day calendar with the 365-day calendar gives a cycle of 52 years in which each day bears a different name derived from elements taken from the other two systems. This major cycle of 18,980 days—52 solar years of 365 days each or 73 divination years of 260 days each—is known as the "calendar round" and was the largest time-measuring unit for most of the Mesoamerican peoples during late pre-Columbian times. Unlike the Mixtecs and Aztecs, the Mayas were familiar with different systems and used other units for measuring longer periods of time, but they were an exception among the great pre-Columbian cultures.

Hieroglyphics

As we have seen, the calendar days were identified by names, some of which designated numbers. That is how Indian diviners still express them in their own languages. The pre-Hispanic Mayas could also write all the days of the year, of the divination calendar and the calendar round in hieroglyphic script. Four hieroglyphic books or codices from that time have survived, and are today conserved in Paris, Dresden, Madrid and Mexico City.

Countless stone inscriptions, a few wall paintings and many painted clay pots and sherds are other sources of information about this highly original writing system.

The simplest way of writing numbers between 0 and 19 consisted of using dots for units and lines for fives in an additive system (**figure 1**). For higher numbers an additional symbol for 20 was used. A positional system was used to write numbers higher than 40, with an extra symbol equivalent to our zero identifying the unoccupied places (see photo page 24). Each place represents a power of 20, until the third place in which a factor of 18 is used. Thus, the order of positional values was as follows: first place, 20^0 (=1), second place, 20^1 (=20), third place, 18 x 20^1 (=360), fourth place 18x20^2 (=7,200), fifth place 18x20^3 (=144,000) and so on.

Counting the days

At an early stage, certainly no later than the beginning of the Christian era, the Central American Indians invented a new way of calculating time: the day number ("*cuenta larga*", or "long count"). This system, which is independent of the calendar cycles described above, consists of

numbering the days continuously from a more or less mythical date far in the past. This extremely accurate dating system has proved to be of invaluable assistance to modern researchers, ever since scholars in the early twentieth century succeeded in correlating it with our own calendar. Its primary aim was to help the Mayas codify major historic dates concerning their rulers or deities.

Other calendar cycles

The Mayas of the classical period used other cycles for historical, divinatory and speculative purposes. For example, a cycle of days or nights devoted to nine deities is known from hieroglyphs G_1-G_9. Furthermore, the combination of short 7, 9 and 13-day cycles, each of which designated a category of gods, was used to come up with a complex divination cycle of 819 days.

Astronomy

The astronomy of the Mayas was not limited to observation of the stars and approximate predictions of the movements of the heavenly bodies. Using their sophisticated numerical systems and various tabular calculations in conjunction with the hieroglyphic script, Mayan astronomers were able to perform complex calculations with figures running into millions.

Their efforts were focused primarily on the sun and the moon. Different year lengths were used for different sorts of calculations. Normally they took the conventional 365-day year as a basis. However, years with a length of 364 days are also encountered, as are years of $365\frac{1}{4}$ days, similar to our own Julian calendar.

The moon played a prominent role in stone inscriptions, which often begin with a day number followed by the phase of the moon and the day's position in a calendar of six lunar months (see photo below left).

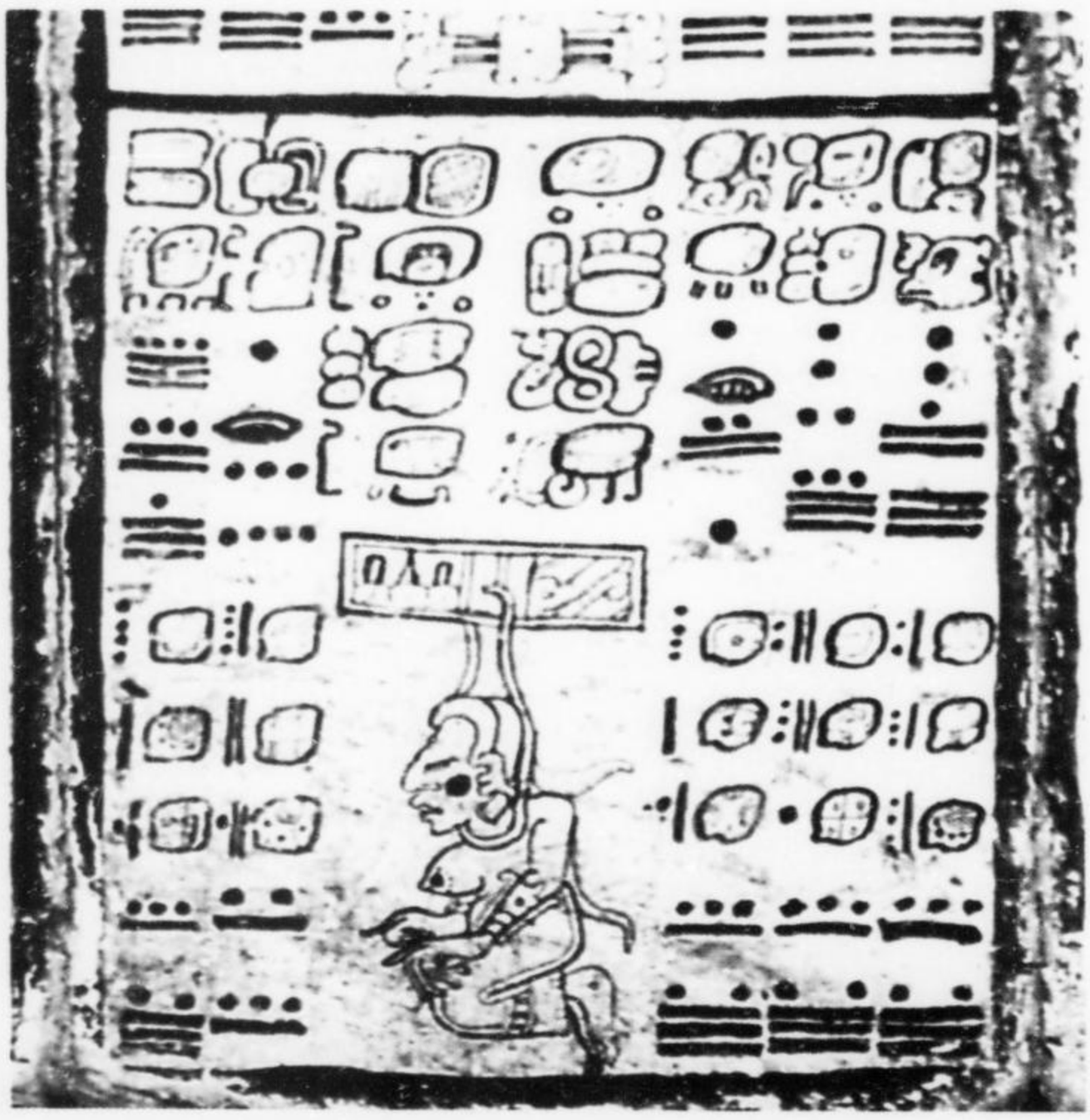
Mayan astronomers also calculated the synodic period of the planet Venus, and the figure of 584 days at which they arrived is astonishingly close to the modern astronomic value. But they went still further. A set of tables in the Dresden Maya codex cites correction factors to allow for the fractional deviations from this value, which can only be observed after decades and even centuries. Researchers also suspect that the Mayas were familiar with the synodic period of other planets, such as Mars and Jupiter, but this has not been proved conclusively.

A springboard into pure mathemathics

For the Maya, all the calendar and astronomic cycles and systems were ultimately used for divination and religious or speculative purposes. Their calendar experts constantly strove to establish a relationship between the cycles by permutation, using the lowest common multiple and other methods, to predict the future and connect the present with historical dates. In this way they could also learn something about the destiny of their clients—the ruler and private individuals.

These practical goals often served as a springboard for complex calculations and research which transcended their original purpose. For example, some of their calculations were projected so far into the past or future that the primary purpose must have been to quench the calendar priests' own thirst for knowledge and desire to explore the limits of their mathematical system. It is therefore reasonable to assert that the Mayas, like the Babylonians, Greeks, Arabs and Indians before and after them, had entered the realm of pure mathematics. ■

Below, detail from a Mayan manuscript conserved in Dresden (Germany). The columns of numbers to left and right of the female figure designate the length of lunar half-years. Above the figure the sign for zero (in red) appears twice.



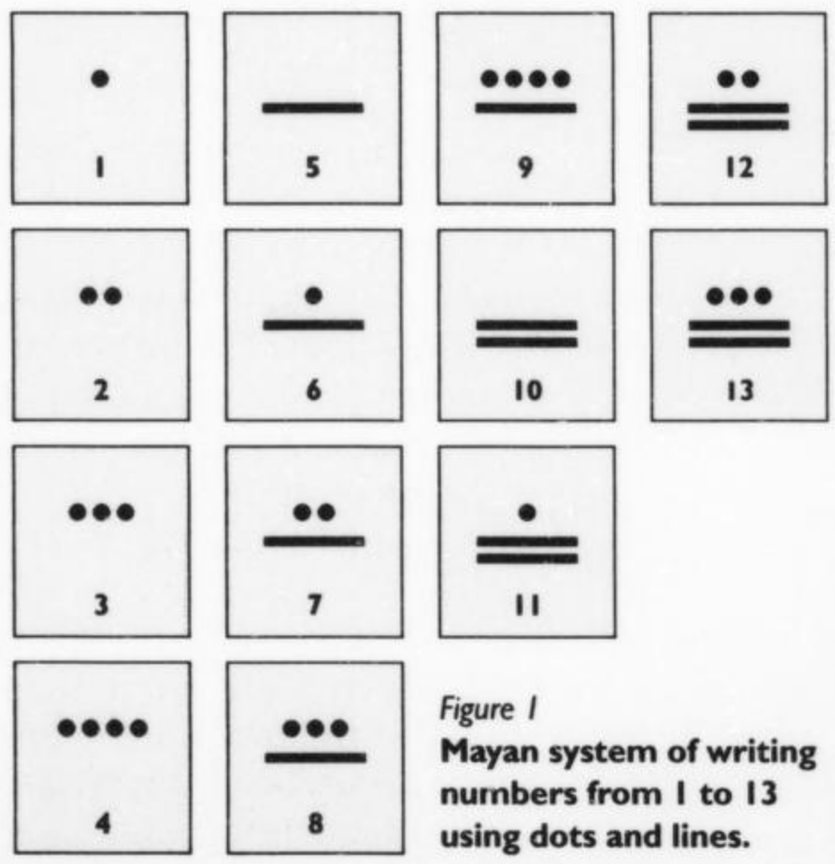
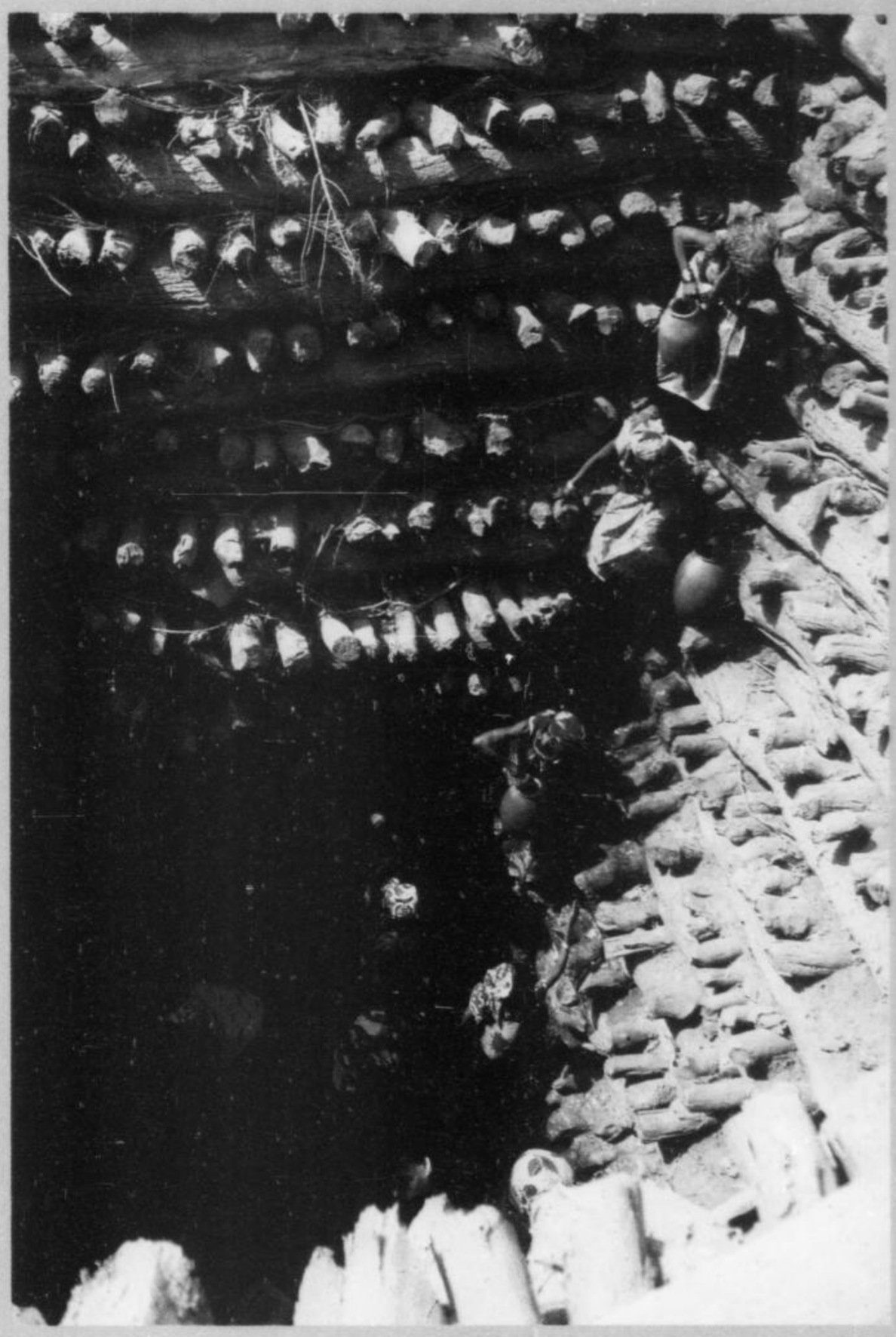


Figure 1
Mayan system of writing numbers from 1 to 13 using dots and lines.

THE UNESCO COURIER — NOVEMBER 1993

UNESCO: HELPING TO SAVE THE EARTH

BY FRANCE BEQUETTE



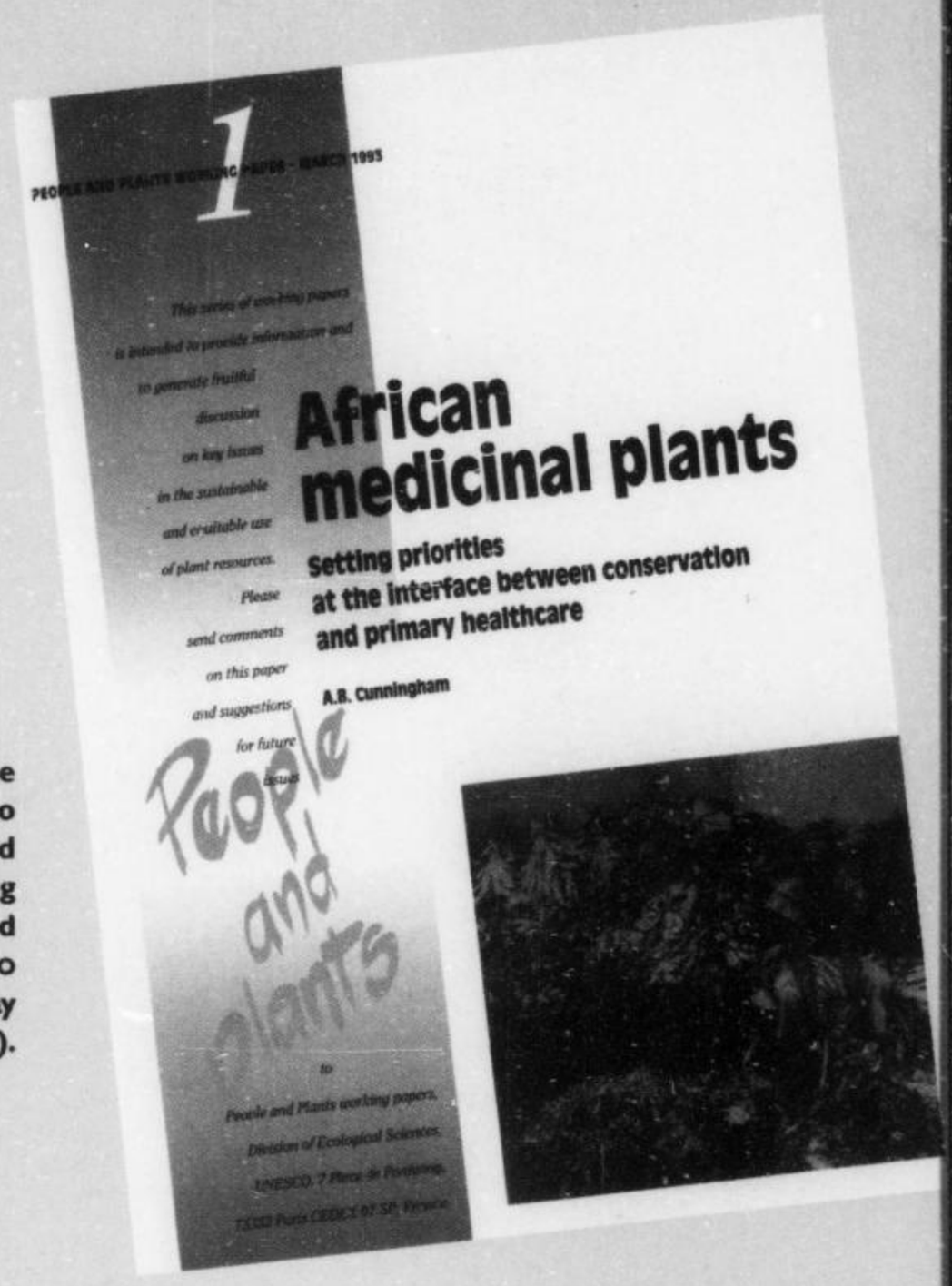
Women at the well in Niger

UNESCO regards the environment as one of its top priorities, and by virtue of its four fields of competence—education, science, culture and communication—it is involved in environmental issues on a wide range of fronts.

"UNESCO started doing in-depth work in the aftermath of the major United Nations Conference on the Environment held in Stockholm in 1972," says Victor Kolybine, who is in charge of the Organization's activities in environmental education. "In collaboration with the United Nations Environment Programme (UNEP), we launched an international programme on environmental education in which the concept of the natural environment was widened to include socio-economic and cultural dimensions. A key idea was that environmental protection is compatible with ecologically sound development."

Today UNESCO and UNEP are still using a wide range of methods to improve awareness of environmental issues. Twenty-seven young people from various northern and southern countries have designed and illustrated a version of Agenda

UNESCO: HELPING TO SAVE THE EARTH



Covers of the first two "People and Plants working papers" issued by UNESCO (March and May 1993).

21, the action plan adopted at last year's UN Conference on Environment and Development, adapted for 7- to 12-year olds. The book, entitled *Rescue Mission: Planet Earth*, will be published at the end of the year by Kingfisher (UK). Another innovative project is being planned by the International Humour Centre in Granada, Spain, which in April 1994 will publish a book of cartoons by famous artists and informative texts in Spanish, English and French.

To promote better understanding of the the complex interrelationships between human activities and the environment, UNESCO makes a point of breaking down the barriers between its various fields of activity, with the social sciences joining forces with the exact sciences and economics. University chairs in sustainable development will be established to provide multidisciplinary education. Programme specialist Christine von Furstenberg explains: "Training nothing but overspecialized experts, as is done everywhere today, prevents the co-operation between researchers and practitioners that is vital in many disciplines."

This pioneering multidisciplinary approach is intended not only for those with specialized qualifications in the exact, natural and social sciences but also for decision-makers, civil servants, engineers, journalists and the interested public. The holder of a UNESCO chair co-ordinates the teaching of several colleagues from different disciplines, and offers sixteen courses leading to a degree. Outlets include national, international and non-governmental organizations. The first chairs already exist. One is in Granada (Spain), another in Quebec, and a third is shared between two universities in Australia and Thailand.

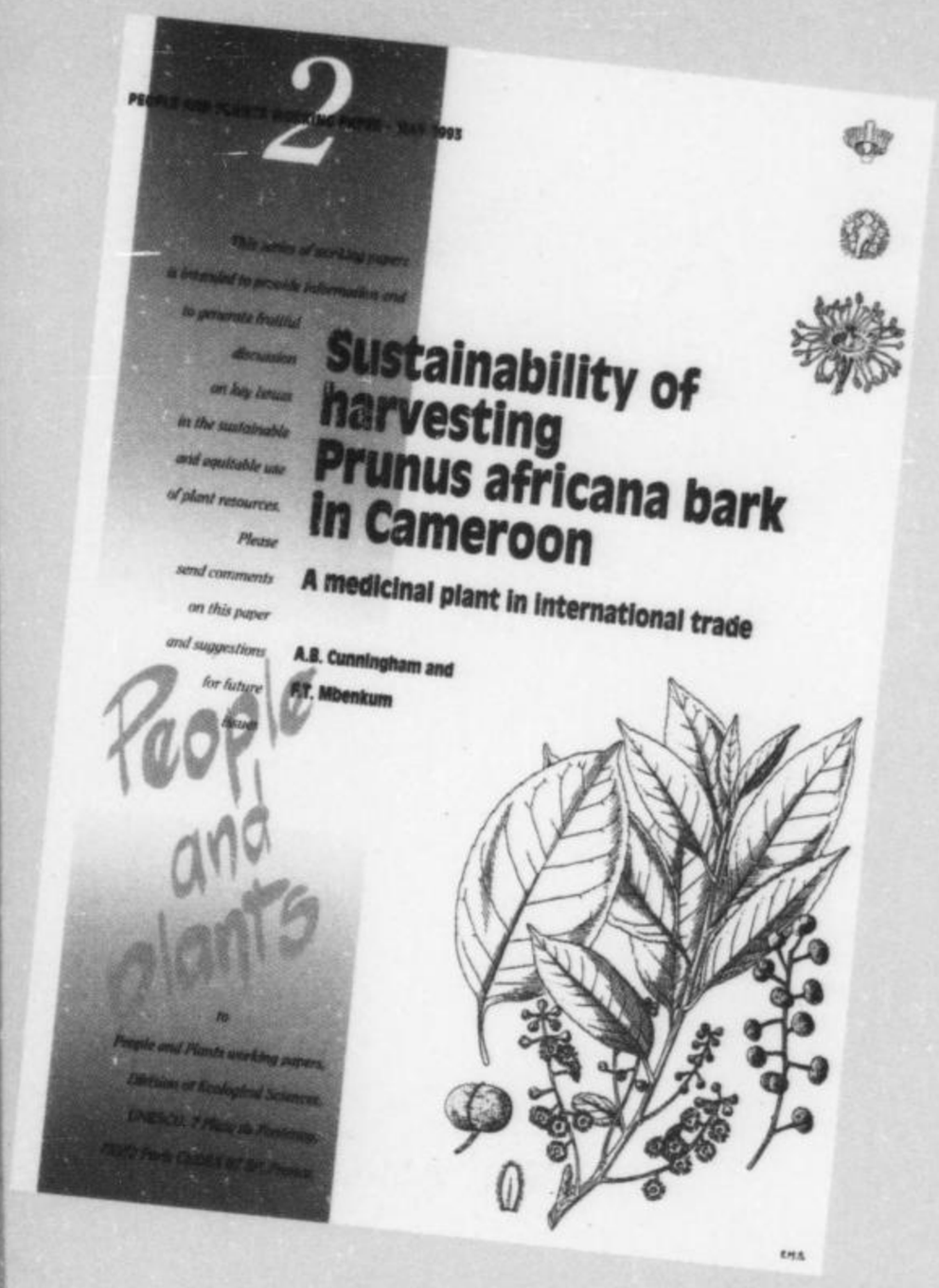
Since 1971 UNESCO's "Man and the Biosphere" (MAB) programme has been an outstanding tool for understanding and protecting terrestrial ecosystems. Its purpose is to study the impact of human activities on the biosphere and the means that can be employed to prevent further damage. MAB has established an international network of 300 "biosphere reserves" covering a total of 164 million hectares in 75 countries.

The reserves are not static, unpopulated ecological museums. They have been created to conserve and monitor representative samples of the planet's major natural and semi-natural ecosystems, offer research opportunities and ensure that local people benefit from the resources of their area without exhausting them. Examples include the Maya forest reserve in Guatemala, the Central Californian coast reserve in the United States—a complex terrestrial and marine environment—and the National Park of Tassili N'Ajjer in Algeria, which is famous for its cave paintings.

Each reserve has a protected "core" area which is surrounded by a buffer zone. However, this system of protection is only effective if the government of the country in which the reserve is located has the political will to respect it. In Africa recently an oil company was given permission to carry out extensive drilling operations in a reserve, wiping out conservation efforts.

Other, less well-known environmental programmes include "Diversitas", which studies terrestrial and marine biodiversity, and "People and Plants", which was launched jointly with the Worldwide Fund for Nature (WWF) and the Royal Botanic Gardens in Kew

Cover of a Turkish environmental education handbook for teachers. The book was prepared with assistance from a UNESCO expert.


2
Sustainability of harvesting Prunus africana bark in Cameroon
A medicinal plant in international trade
A.B. Cunningham and P.T. Mbenkum
People and plants

(UK) to promote the sustainable and equitable use of plant resources by providing support to ethnobotanists from developing countries. Nature can provide a cornucopia of medicines for those who know how to use it.

For over a year local people have been helping ethnobotanists, forest managers and traditional practitioners conduct an inventory of plant life in particularly rich ecosystems in the Caribbean, Madagascar, Bolivia, Brazil, Mexico, Cameroon and Uganda. In Kinabalu Park, Sabah (Malaysia) a three-year programme is cataloguing the many uses of palm trees and medicinal plants. A detailed manual describing the plants and their chemical composition, medicinal or toxic properties and uses will be published. The objective is to make traditional plant resources, which poor and isolated populations rely on for most or all of their medicine, available to the greatest number of people.

The Intergovernmental Oceanographic Commission (IOC) works on a completely different scale. It participates in international climate and ocean observation research programmes aimed at forecasting natural disasters such as floods, cyclones and tsunamis (seismic sea-waves).

UNESCO is also concerned with the sustainable management of coastal areas threatened by urbanization, pollution, the spread of tourism and transport systems and the destruction of mangroves and coral reefs. "Insula" and "Archipel" are two programmes exclusively concerned with promoting sustainable development of islands. Their aim is to piece together a vast network, which is already beginning to take shape between Ouessant (France), Estonia, Majorca (Spain) and the Bijagos Islands (Guinea-Bissau). The programme, based on sharing experience and solutions, has aroused interest in the United States, Guadeloupe and Finland, which are considering taking part in it.

Insularity is also a concern of UNESCO's International Hydrological Programme (IHP), which seeks to rationalize fresh water use and management on tropical islands. IHP's wide-ranging mandate includes evaluating the link between climatic change and water resources and helping Member States, especially those in arid or semi-arid zones, to study the water cycle and improve the management of water resources degraded by human activity.

This is only a selection of UNESCO's many environmental activities. A forthcoming *Greenwatch* will take a further look at the Organization's work in this field. ■

READING LIST:

✔ The ***Environment and Development Dossier*** (in French, English and Spanish) presents clear, precise scientific information and is available free to governments, university teachers and students and the media. Please contact the UNESCO Environmental Programme Coordinating Office, 1 rue Miollis, 75732 Paris Cedex 15, France.
Tel: (33 1) 45 68 10 00, Fax: 45 66 90 96

✔ **"UNESCO Sources"**: *Rio One Year Later*, no. 47, May 1993 (English, French, Spanish and Catalan).

✔ ***Tsunami Warning!*** a cartoon book produced by the Intergovernmental Oceanographic Commission's International Co-ordinating Group for the Tsunami Warning System in the Pacific. Available from the International Hydrological Programme, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France.

✔ ***African Medicinal Plants***, by A.B. Cunningham (in English). "People and Plants", Division of Ecological Sciences, UNESCO, 7 place de Fontenoy, 75351 Paris Cedex 07, France.

FRANCE BEQUETTE
is a Franco-American journalist specializing in environmental questions. Since 1985 she has been associated with the WANAD-UNESCO training programme for African news-agency journalists.

Cover of the informational cartoon book *Tsunami warning!* See reading list above.

GOURMET GARBAGE

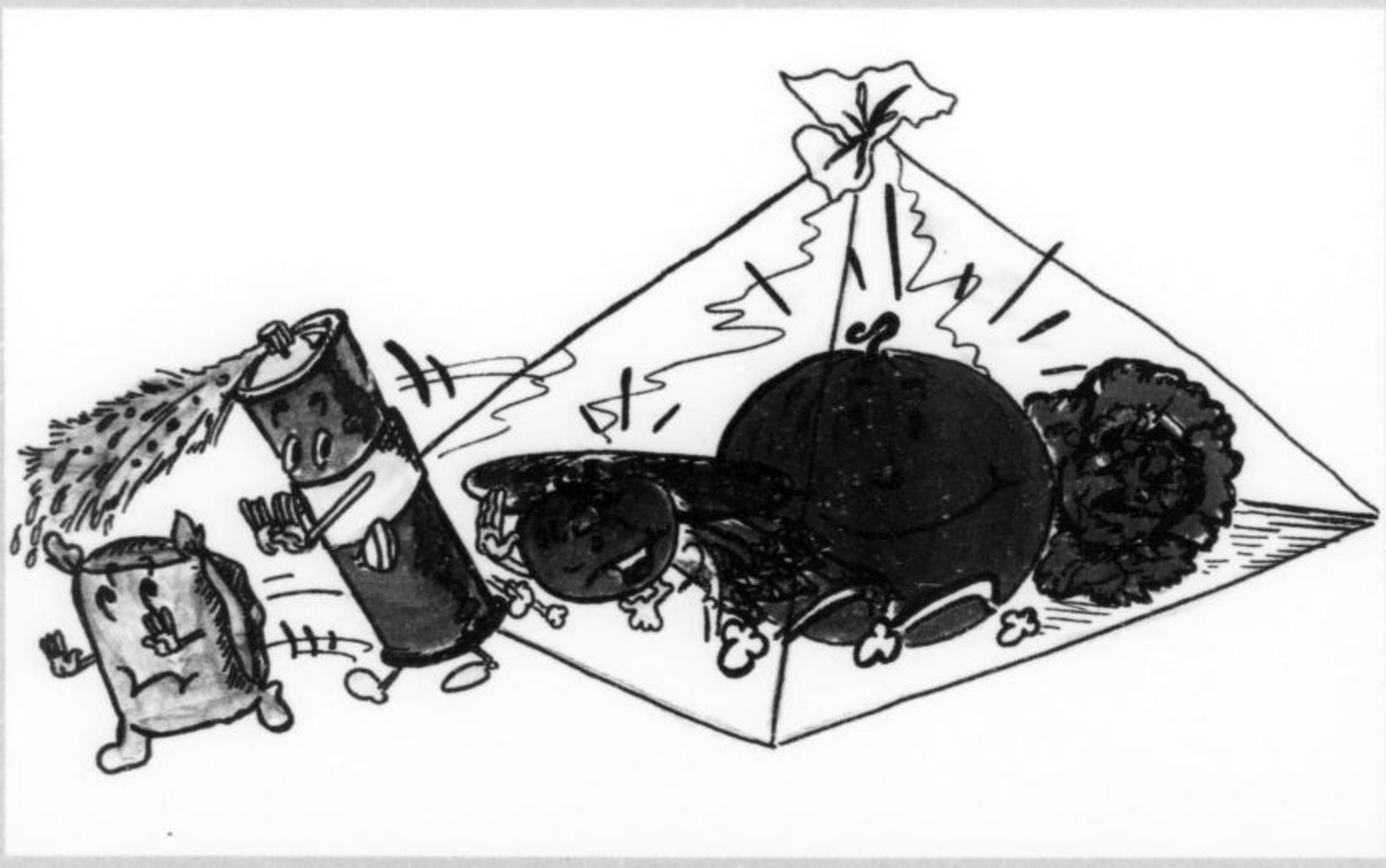
Delicious mushrooms can be grown on plant and agro-industrial waste. This lucrative practice has economic potential for developing countries, as Cameroon has discovered. This West African state is currently growing varieties that are not only tasty but also rich in protein. Up to 1.25 kilos of mushrooms can be grown on one kilo of straw. ■

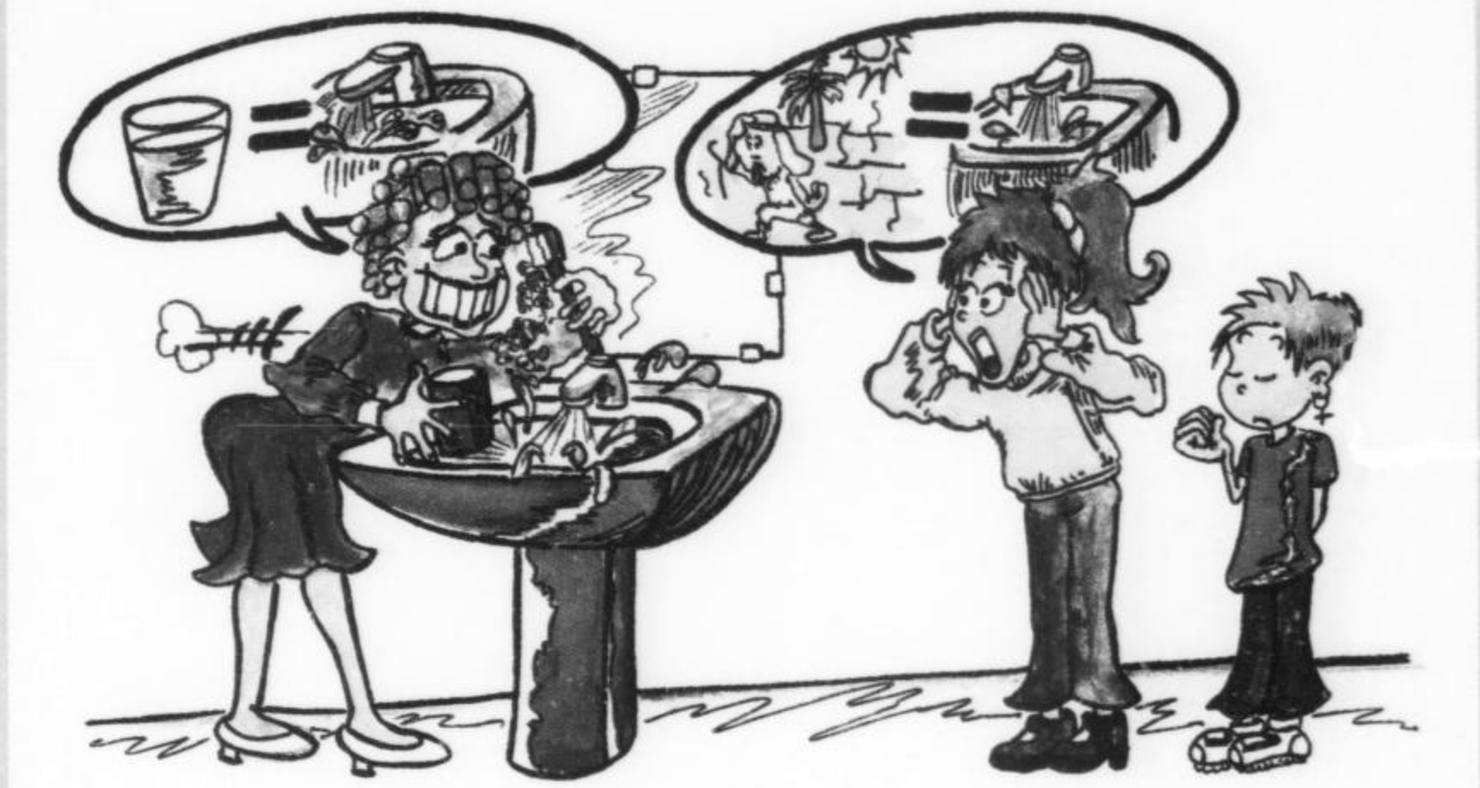
BANGKOK GOES ORGANIC

A Thai company, Agro-Town Co. Ltd., is beginning to market fruit and vegetables grown in accordance with the Codex organic farming standards set by the World Health Organization (WHO) and the UN Food and Agriculture Organization (FAO). Lettuce, tomatoes, cucumbers, watermelons and asparagus will be grown without pesticides or chemical fertilizers. Despite prices that are somewhat higher than those paid for non-organic produce, the company has found outlets not only in Bangkok but in South Korea, Singapore, Malaysia, Japan and the United States. ■

TRANSFORMING ESTONIA INTO GREEN-LAND

Located on the Baltic coast in north-eastern Europe, Estonia today suffers from industrial pollution whose impact extends beyond its borders, notably contaminating the waters of the Gulf of Finland. Several Estonian cities and many villages have no waste water treatment facilities. And yet Estonia was once an environmental pioneer. As early as 1910 a bird sanctuary was created on the islands off the country's west coast which have since become a biosphere reserve. Before 1940 Estonia boasted 47 nature reserves, 80 protected parks and 40 protected forests. Lahemaa national park, created in 1971, was the first of its kind in the Soviet Union. One of the present government's priorities is to save the country's natural areas, which include islands, forests and lakes that are home to an extraordinarily rich variety of nearly 9,000 plant and over 12,000 animal species. ■





"LITTLE GREEN LIES"

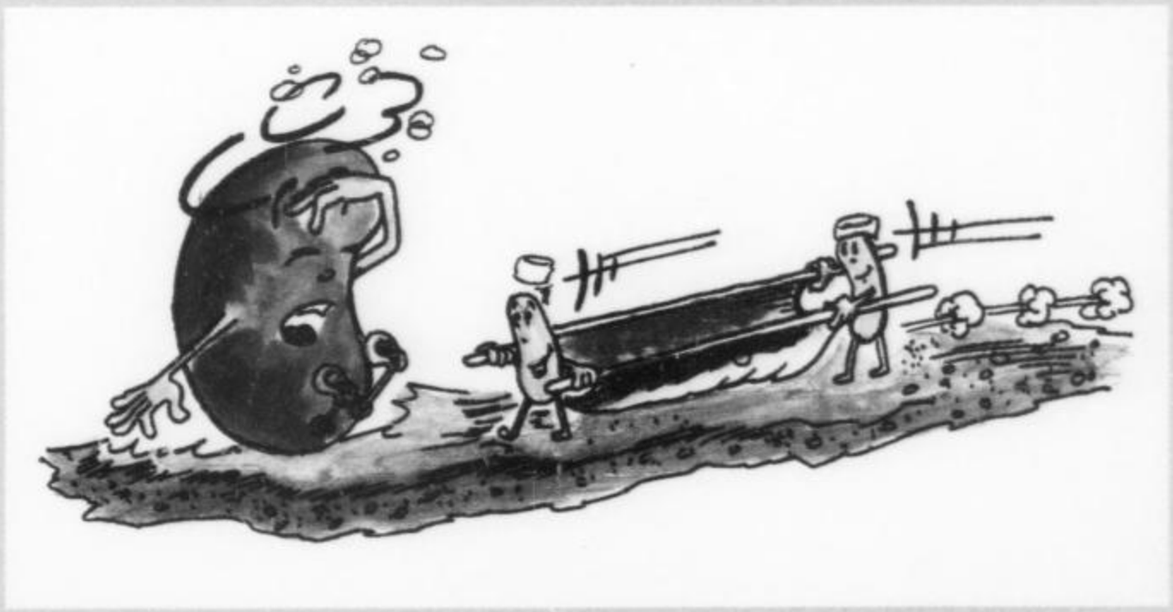
An American environmental policy analyst, Jonathan H. Adler, claims that some children are being taught on ecologically unsound principles so that, for instance, they criticize their parents for using objects made of plastic rather than natural materials or for leaving the tap running while brushing their teeth even when there is no water shortage. He also refers to a textbook which claims that the world is hotter now than it has ever been, without mentioning that temperatures have only been recorded scientifically for a century. Mr. Adler's point is that educators should base their teaching on scientific facts and beware of political indoctrination. ■

INDIAN FARMERS SAVE THEIR SOIL

For years overgrazing and deforestation devastated the mountain slopes overlooking the village of Sukhomajri, located in the Shivalik foothills of the Himalayas. The erosion rate reached 900 tons of soil per hectare, and fertile, river-borne mud was gradually filling an artificial lake downstream. In 1977 a soil conservation specialist unsuccessfully attempted to change the villagers' behaviour. Things only began to change when a village elder suggested to the specialist that a small dam of earth should be built to provide the village with water. In return for the water the village herdsmen agreed to respect the hillside and to pay a tax when they gathered fodder there. Within five years the grass and trees had grown back, and today irrigation has doubled the production of cereals, which are now harvested three times a year instead of once, as before. Buffaloes have replaced goats and the village now sells over $10,000 worth of milk annually. ■

BACTERIA GIVE BEANS A BOOST

Beans are a major food resource in the Andes. The International Center for Tropical Agriculture in Cali, Colombia, has announced the discovery of bacteria that enable bean plants to draw the nitrogen essential for their growth directly from the air. Farmers can buy a bacteria-peat mix called *Rhizocaj* for one-tenth the price of industrially-manufactured nitrogen fertilizer. They mix bean seeds with sugar and water, add *Rhizocaj*, mix the seeds again until they are coated with the blend and plant them. The best results have been achieved in the mountains, precisely where successful farming has been most difficult. *Rhizocaj* has already been tested in Peru and Bolivia and, if funding permits, will be tested in the highlands of Ecuador. ■



Making something out of nothing

by Pierre-Sylvain Filliozat

By inventing the zero, India became the birthplace of modern arithmetic

In India mathematics has not always been linked to writing. The earliest surviving written document dates from the third century B.C., but India certainly had an advanced civilization many centuries before that, and scientific knowledge formed part of it. Most knowledge was transmitted orally. This ancient learning preserved in human memory makes up the corpus of the great religious texts known as the Vedas, which incidentally contain evidence of mathematical knowledge. The Vedas are written in an archaic form of Sanskrit. Like all Indo-European languages, Sanskrit has decimal numerals and individual names for the nine units, as well as for ten, a hundred, a thousand and higher powers of ten (**figure 2, page 33**).

Kushan coin with inscription in the ancient Indian *brâhmî* script (first century A.D.).

Numerals	Value	Numerals	Value
∝ =	12	-	1
—	1	∝ =	12
⊤ ≍ ⅂	1700	⊤o⊤	21,000
≍ Φ ?	189	—	1
∝ ⅂	17	⊤⊣	60,000
⊤∝ ⊤	11,000	⊤∝ -	10,001
⊤	1,000	≍ -	101
∝ =	12	⊤ ≍	1,100
—	1	≍	100
⊤o⊤⊣ ≍	24,400	≍ -	101
⊤⊣	6,000	⊤ ≍ -	1,101
—	1	⊤ ≍ -	1,101
—	1	≍ -	101
—	1	⊤ =	1,002
≍	100	⊤ -	1,001

Figure 1
Numeral signs and their values as attested by the Nâneghât inscriptions (first century B.C.).

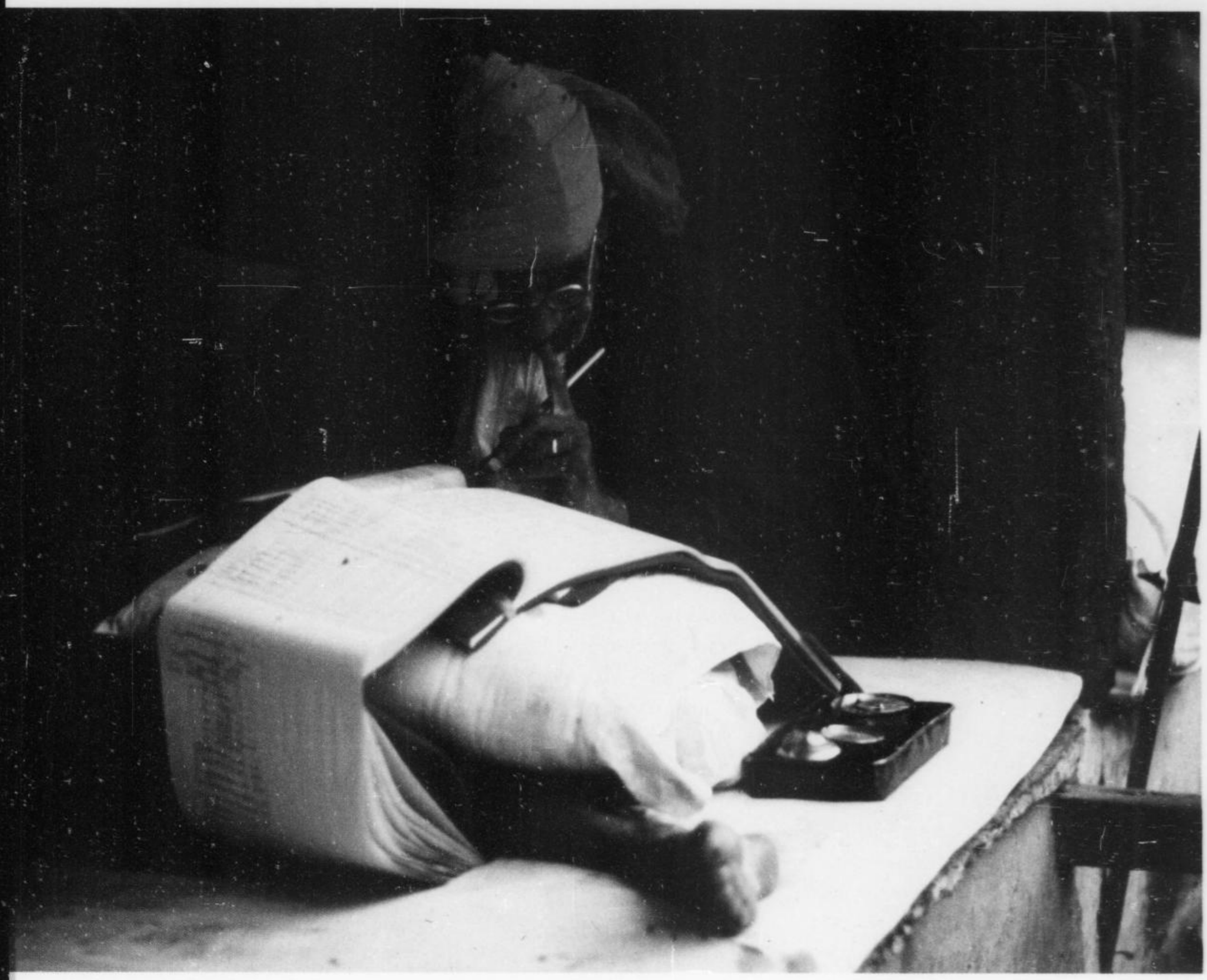
The names of the tens are derived from those of the units, somewhat modified and with the addition of a suffix. Examples are *vimçati* 20, *trimçat* 30, *catvârimçat* 40. The other numerals are formed from these components. The names for the hundreds, thousands and so on consist of a unit name followed by *çata* or *sahasra. Dve çate* (dual), for example, means 200, and *trini-sahasrani* (plural), 3,000.

In Sanskrit grammar the qualifier in a compound word precedes the qualified. In the case of compound numerals the number of the higher order is regarded as qualified by the lower. Eleven, for example, is ten qualified by the addition of one, giving the compound *ekâ-daça*, and similarly *dvâ-daça* is 12, *trayas-trimçat* 33 and so on. The number is divided into components, with the smallest coming first. Units are followed by tens and so on.

The advent of writing

We do not know when, how or by whom writing was introduced into India. All we know is that as early as the third century B.C. two scripts were in use. One, called *kharoshtî,* was derived from Aramaic. It was used in the extreme northwest of the sub-continent, but soon fell into disuse. The other, known as *brâhmî,* seems to have originated in India itself. It is the forerunner of all the scripts now in use in the Indian sub-continent and in southeast Asia. The earliest records (from between the third century B.C. and the third century A.D.) of figures transcribed into this script reveal a notation system that corresponds fairly closely to the pronunciation system.

There is one sign for each digit, and so there are nine signs for the nine units, an entirely different sign for each of the tens (10, 20, etc.), another sign for 100 and yet another for 1,000. Compound numbers are represented by com-



An Indian merchant does his accounts in Ajmer (Rajasthan).

binations of symbols. The *brâhmî* script reads from left to right, and combinations of signs are written in that direction, starting with the highest value. Here there is a difference between the written and the spoken language. The scribe starts with the highest component, whereas the speaker starts with the lowest. For example, the number 13 is pronounced *trayo-daça*, or "three-ten", but is written "ten-three".

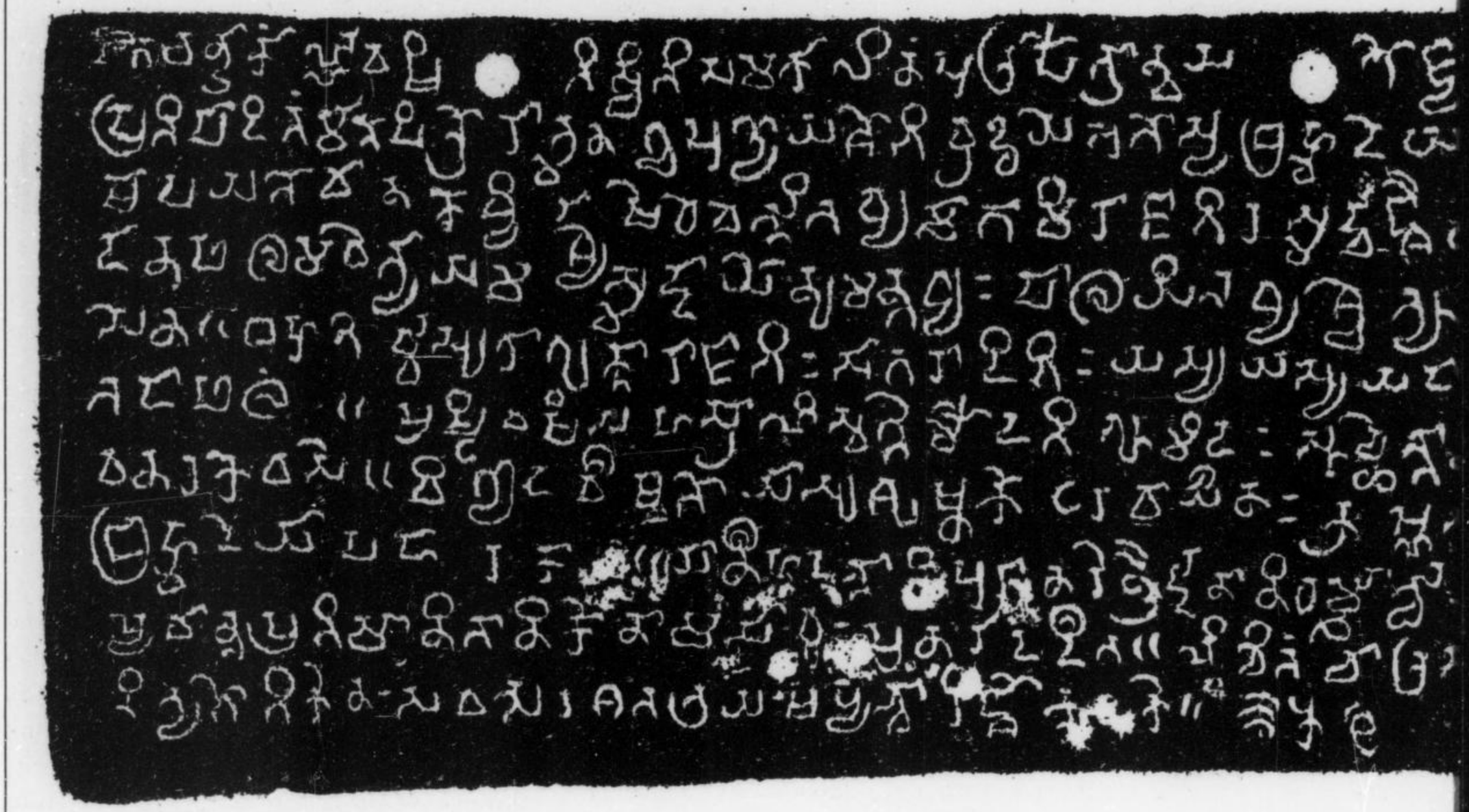
Combinations of components are usually produced by juxtaposing signs, in some cases by ligatures. Whereas there are different signs for each of the tens, for the hundreds there is just the sign for 100 plus the sign for the number of hundreds, and likewise with the thousands.

At this stage we cannot yet speak of positional notation. There is a juxtaposition of the numeral signs which when added together give the desired number. This is exactly in keeping with the structure of the language (**figure 1**).

The zero and positional numeration

In the decimal positional system of numeration the tens, hundreds and thousands are not represented by different signs but by the same digit signs placed in different positions. Only then does position become significant. It alone shows which are the tens, which the hundreds and which the thousands. Such a system needs only ten signs, the digits from 1 to 9 and a zero—or at least a blank space.

There is no satisfactory documentary evidence as to how and in what exact period this system was discovered in India, and how it developed. The earliest reference to a place-value notation is a literary one. Vasumitra, a Buddhist writer and leading figure at a great religious council convened by King Kanishka (who reigned over the whole of north and north-west India at the end of the first or the beginning of the second century A.D.), maintained in a book on Buddhist doctrine that if a substance that exists in all three time dimensions (past, present and future) is regarded as something different every time it enters a new state, this change is due to the alterity of the state, not to



Charter dating from 596 A.D. The last three signs on the last line represent the figures 346.

its own alterity. He illustrated this idea by speaking of a marker which in the units position counts as a unit but in the hundreds position counts as a hundred. He did not specify the nature of the marker.

This may be a reference to a kind of abacus. The marker might have been an object that could be placed in a column or square, where its position gave it the value of a power of ten. Or it could be a mark in the sand, in the case of sums written on the ground. Indian accountants are known to have liked the simplicity of this method. In some parts of southern India village astrologers can still be seen doing calculations by placing cowrie shells in columns drawn in the sand. Whatever the form of the abacus, Vasumitra's reference implies the existence of a notation that took account of positional value.

The same is true of the zero, the use of which in India is known from literary references predating the earliest written examples. The zero forms part of the positional system of numeration. Originally it seems to have been a gap in a column resulting from the absence of a figure or marker in the space reserved for an order of the power of ten. This is shown by the use of one of the words meaning empty, *çûnya* or *kha*. The word *kha* occurs in a treatise on metrics by Pingala, in which he sets forth a rule for turning binary numbers into decimal numbers. Pingala's dates are unknown, but quotations from his works are found from the third century A.D. onwards, and so he must have lived earlier than that.

That a dot came to be used to indicate an empty space we know from a Sanskrit storyteller, Subandhu, who probably lived in the sixth century A.D. To denote the zero Subandhu used the compound noun *cûnya-bindu,* literally "empty point", in other words a dot indicating an empty space in a column.

The zero itself appears in a deed of gift, carved on copper plates, from King Devendravarman of Kalinga (Orissa, in eastern India). The document is dated in letters and figures : "*samvacchara-çatam trir-âçîte* (100) 83 *shravane masi dine vimçati* 20 *utkîrnnam*", literally "carved a hundred and eighty-three years (100) 83 (having passed) the twenty day 20 in the month of *Shravana*". The number 183 is written as three signs, the sign for a hundred and then the figures 8 and 3. The number 20 is written with the figure 2 and a zero in the form of a small circle. The period specified in this document began in 498 A.D., so that it dates from the year 681 A.D.

Positional notation, and the zero in the form of a big dot or small circle, are found in inscriptions in southeast Asia, at Sambor (Cambodia) and Kota Kapur (Malaysia), where the earliest records go back to the seventh century A.D. The scripts used in these countries are all derived from Indian scripts, and their system of writing numbers is undoubtedly the Indian system. All

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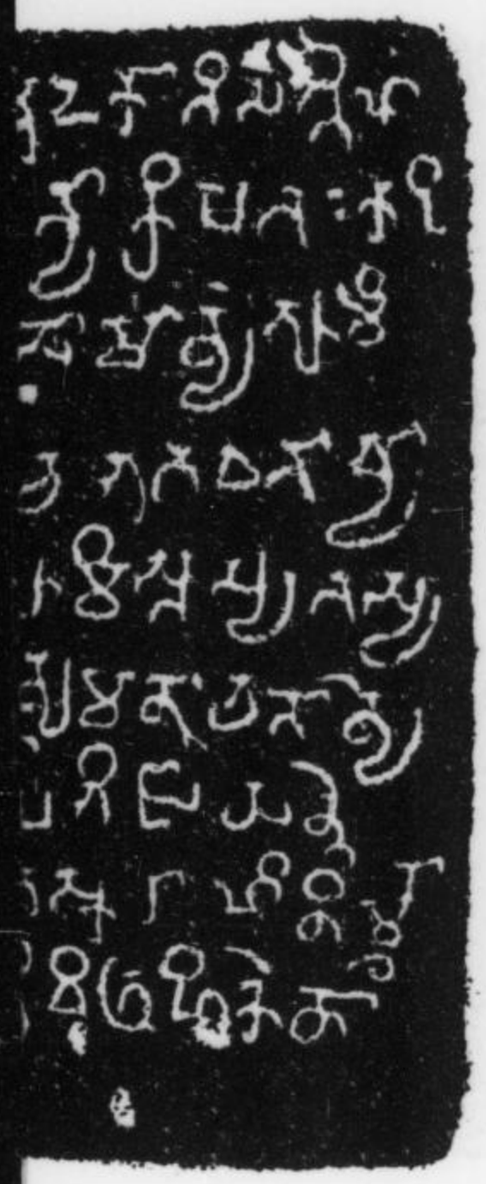

Below, numerals written in *devanâgarî* (script used for Sanskrit, Hindi and other Indo-Aryan languages) in a "magic square" painted on a wall in Ujjain (Madhya Pradesh, India).

these documents show that by the late seventh century the positional system and the zero were in general use not only in India but in all the countries to which Indian civilization had spread as well.

Notation using nine digits and a zero seems to have quickly taken the lead for inscriptions, but it never completely superseded the old system, which survived until recently in manuscripts, and in southern India even in early twentieth-century printed books.

■ *Words standing for numerals*

A mixed notation, in which features of the old system are combined with or alternate with characteristics of positional notation, was also known and used in India. In this system number names are replaced by words with numerical connotations. For example, two is replaced by "eyes", "arms", "wings" or "twins", four by "oceans" (there being four oceans in Indian geographical mythology), ten by "fingers", thirty-two by "teeth", hundred by "human life-span", zero by "empty space", and so on. These words are arranged as they would be in speech, so that in a compound number the lowest numerals come first. In other words, the order is opposite to that used in writing. For instance, the number 4,320,000 is pronounced *khaca-tushka-rada-arnavâh*, which literally means "tetrad of empty spaces-teeth-oceans", or 0—0—0—32—4.

Figure 2. Number names in Sanskrit

eka	1	çata	100
dvi	2	sahasra	1 000
tri	3	ayuta	10 000
catur	4	niyuta	100 000
pañca	5	prayuta	1 000 000
shat	6	arbuda	10 000 000
sapta	7	nyarbuda	100 000 000
ashtan	8	samudra	1 000 000 000
nava	9	madhya	10 000 000 000
daça	10	anta	100 000 000 000
		parârdha	1 000 000 000 000

This example is taken from the *Sûrya-siddhânta*, an astronomical text which takes account of data observable in the fourth century A.D. It is one of the earliest records of this mixed notation, which enjoyed great popularity throughout the history of Sanskrit literature. Even among mathematicians and astronomers it seems to have been the preferred method of expressing numbers. Its advantage was that it allowed variation of vocabulary. Sanskrit has ten or so common words for eyes, whereas there is no synonym for the number 2. Sanskrit technical and scientific literature was usually written in verse, so that authors needed to command a wide vocabulary in order to find words to fit the requirements of prosody.

It would be a mistake to regard this mixed notation as a transitional stage between the old oral system and the pure positional system. It was an artificial method adopted by authors who were familiar with both systems and used them in their writings.

■ *Economy and lightness*

In 662 A.D. a Syriac writer, Severus Sebokt, wishing to show that the Greeks had no monopoly on science, referred to the inventiveness of Indian scholars. The only one of their mathematical skills that he mentioned was their system of reckoning using nine digits. Severus Sebokt's comment points to the greatest advantage of this system, its economy. By reducing the symbols needed for the notation of all numbers to ten—nine digits and a zero—the system achieves the ideal of economy and efficiency. Indian intellectuals were well aware of the advantages of economy. They had a technical term for it—*laghava* or "lightness"—and have cultivated it since Antiquity in various fields of thought.

Hindu-Arab roots of medieval Europe

by André Allard

A written numeration system transmitted to the West from India via the Arab world

At the beginning of Molière's last play, *Le Malade Imaginaire* (1673), the hypochondriac Argan uses a counting-frame—an abacus—to reckon up the cost of the remedies prescribed by his apothecary. He eventually arrives at a total cost of "three and sixty pounds, four sous, six deniers."

This method of counting, which dates back to Antiquity, was quite common in Molière's time. Though written numeration had been known in the Latin West for several centuries, and paper was in general use, the abacus with counters was still often used in the seventeenth and even in the eighteenth centuries. Leibniz used one, and Voltaire's famous correspondent Frederick II of Prussia took it as the pretext for a quatrain:

"Courtesans are counters
Whose value depends on their place :
In favour, millions,
Noughts in disgrace."

The counting-frames still used in the Far East and parts of Eastern Europe (the Chinese *xuanban,* the Japanese *soroban* and the Russian *schoty*) are linear abaci based on the same principle as those of ancient Greece and Rome.

How did counting devices of this kind come to be superseded in the West by figures?

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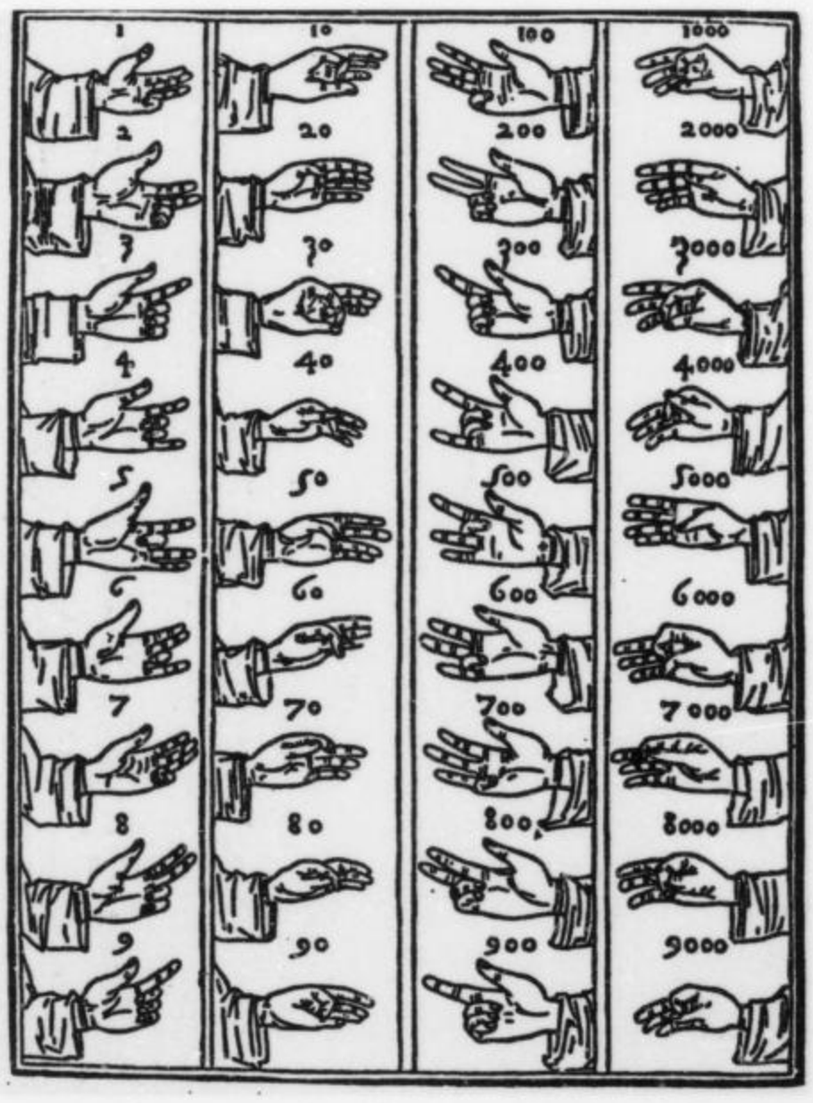
Counters, fingers and Indian numerals

During the early Middle Ages (from the fifth century, which saw the fall of the Roman Empire, to the ninth) Western writers' scientific knowledge was limited to a speculative arithmetic based mainly on the *Introduction to Arithmetic* by the second-century neo-Pythagorean Nicomachus of Gerasa, and a practical method of calculation using counters, not written figures. These counters were remotely descended, via the *calculi* of the Romans, from the pebbles used by the Greeks of Pythagoras's time to represent numbers.

For a long time the only rival to the counter system was reckoning on one's fingers, as described in the seventh century by the Venerable Bede in his brief treatise *De Temporibus* ("On Times"):

"When you say one, bend the little finger of your left hand and dig it into the middle of your palm. When you say two, do likewise with the bent second finger from the little one. . . . When you say five, likewise straighten the second finger from the little one. . . . When you say ten times a hundred thousand, clasp both hands with the fingers interlocked. . . ."

This method of using the hands for counting remained current for a very long time. A detailed description of it (**figure 1**) can be found as late as 1494 in one of the most important mathematical works of the modern era, *Summa de Arithmetica* by Luca Pacioli (Luca di Borgo) which was published at Venice in that year.



Portrait of the Italian mathematician Luca Pacioli (c.1445-c.1510), by Jacopo de' Barbari.

Gerbert of Aurillac, who in 1003 became Pope as Sylvester II, seems to have been one of the first persons to propagate the use of Hindu-Arabic numerals in Europe. He did so by borrowing from the Arabs of Spain the use of an advanced type of abacus with twenty-seven columns, on which counters made of horn could be moved. The counters were usually marked with the first nine numerals.

■ *From Baghdad to Toledo*

In the early ninth century the Abbasid Caliph al-Ma'mun founded at Baghdad an academy called the House of Wisdom, which promoted cultural exchange with India, in particular translations of manuscripts collected by his envoys. The mathematician al-Khwarizmi, in addition to his famous *Kitab al jabr wa'l-muqabala*, the basic text of Arabic algebra, also wrote a "Book of Addition and Subtraction" and a "Book of Indian Arithmetic".

The latter work gave rise to two traditions. One, exclusively Arabic and of the highest quality, reached its peak in the ninth and tenth centuries. The other, equally important, developed later. In twelfth- and thirteenth-century Europe, and especially at Toledo, translators and compilers of Arabic books in Latin played a key role in the development of mathematics in the West, comparable to that played by the Baghdad scholars and translators in the Islamic world.

Under the influence of the new mathematical treatises they wrote towards the middle of the twelfth century, reckoning by abacus, either with counters or in the sand (in which figures could easily be written and erased), and on the fingers gradually gave way to a system based on Indian and Arabic methods. This was "algorism", a word derived from al-Khwarizmi's name.

Based on the nine digits (*figurae* in Latin) and the zero (sometimes called *cifra* in the Latin texts, from the Arabic *sifr,* "emptiness", but more often called *circulus,* "little circle"), algorism made it possible to perform traditional operations on whole numbers (addition, subtraction, duplication, multiplication, division

Figure 1. Numbering by hand
Illustration showing a method of using the hands for counting taken from Luca Pacioli's *Summa de Arithmetica, Geometria, Proportioni e Proportionalità* (1494), a compendium of mathematical knowledge.

	1	2	3	4	5	6	7	8	9	0
12th century "Toledan" numbers	١	٢	٣	٤	٥	٦	٧	٨	٩	٠ / ۦ
"Indian" numbers	١	٢	٣	٤	٥	٦	٧	٨	٩	
Astronomical tables	١	٢	٣	٤	٥	٦	٧	٨	٩	٠ / ۦ

Manuscript, Staatsbibliothek, Munich

	1	2	3	4	5	6	7	8	9	0
13th century	١	٢	٣	٤ / ٤	٥	٦	٧ / ٧	٨	٩	٠
	١	٢	٣	٤	٥	٦	٧	٨	٩	?

Manuscript, Biblioteca Apostolica, Vatican

	1	2	3	4	5	6	7	8	9	0
15th century	1	2	3	4	5	6	7	8	9	0

Book printed by Johann Widmann, Leipzig, 1489

This table shows how the writing of numerals in the West evolved from the two series of figures originating from the eastern and western parts of the Arab world (12th to 15th centuries). The manuscripts conserved in Munich (12th century) and in the Vatican (13th century) show how the two different forms continued to exist side by side. The numerals in Widmann's book (late 15th century) represent the culmination of a process of evolution that is still not fully understood.

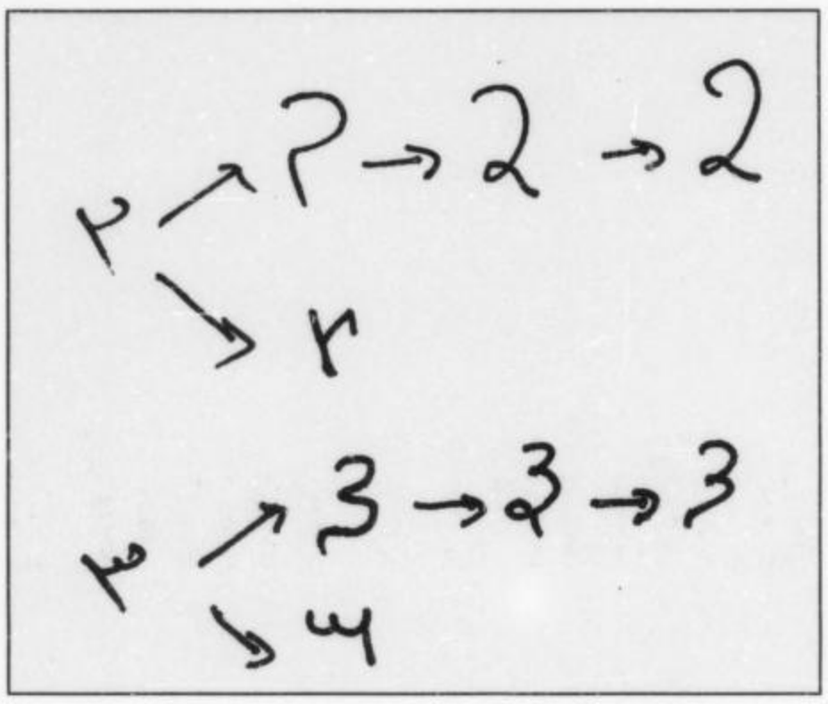


Figure 2.
Turning the numbers 2 and 3 in their eastern Arabic written form through ninety degrees to the left gives a fairly convincing approximation to the western Arabic forms and shows how they may have evolved into the forms familiar to us today.

and extraction of roots) faster and more reliably. Contrary to a view widely held during the Middle Ages and the Renaissance, numerals of Indian origin brought to the West by the Arabs owed nothing to the late Roman mathematician of the sixth century, Boethius.

In the late thirteenth century most of these treatises were eclipsed by the impressive "Book of the Abacus" by the Pisan mathematician Leonardo Fibonacci (Leonardo of Pisa). Contrary to what its title might suggest, this work marked a final break with the abacus tradition. Even more influential were two highly successful works, Alexandre de Villedieu's "Song on Algorism" and Sacrobosco's "The Common Algorism".

For a long time Hindu-Arabic numerals were written in Western manuscripts in a wide variety of ways. From the outset translators were faced with two series of figures, one from the eastern part of the Arab world, the other from the western Arab world. The latter seems to have developed as a result of two factors—the discovery of the principles of Indian arithmetic and the ways in which the abacus was then used. This difference can only be seen in a few Latin manuscripts (**table at top of page**). In most cases Western copyists transcribed forms that were increasingly remote from their originals. Obliged to write from left to right (to which the Arabic shapes did not lend themselves), they gave the figures only a symbolic value and soon distorted their forms. This palaeographical evolution continued until the Renaissance, and may have reflected Visigothic influence. It is particularly striking in the cases of the numbers 2 and 3 (**figure 2**).

■ *The triumph of algorism*

By the tenth century if not before, the ease with which calculations could be done with Indian numerals led the Arabs to improve the technique. Some methods spread in other ways than through textbooks of arithmetic. Probably on one of his many journeys, Leonardo of Pisa became familiar with the Arabic method of calculating called "houses", and used it to devise his own "checkerboard" method—a set of squares with all the numerals written in them, on which diagonals were drawn. This became very widespread.

At the dawn of the Renaissance a wood engraving that was to become famous was made at Freiburg-im-Breisgau. It showed the "Philosophical pearl" (*Margarita Philosophica*). On the left a money-changer representing Boethius is operating with Hindu-Arabic numerals and looking cynically at one of his colleagues, who with a shamefaced expression is working with an abacus and counters according to the Pythagorean tradition. Behind them, Dame Arithmetic shows clearly where her own preferences lie: her dress is actually spangled with figures.

There could be no better illustration of the triumph of figures in the medieval West, even though the latter all too rarely acknowledged its indebtedness to the Indian and Arabic civilizations which bequeathed it, among other legacies, this remarkable tool. ■

Words, gestures and symbols

by Paulus Gerdes and Marcos Cherinda

Africa has a rich variety of traditional counting methods

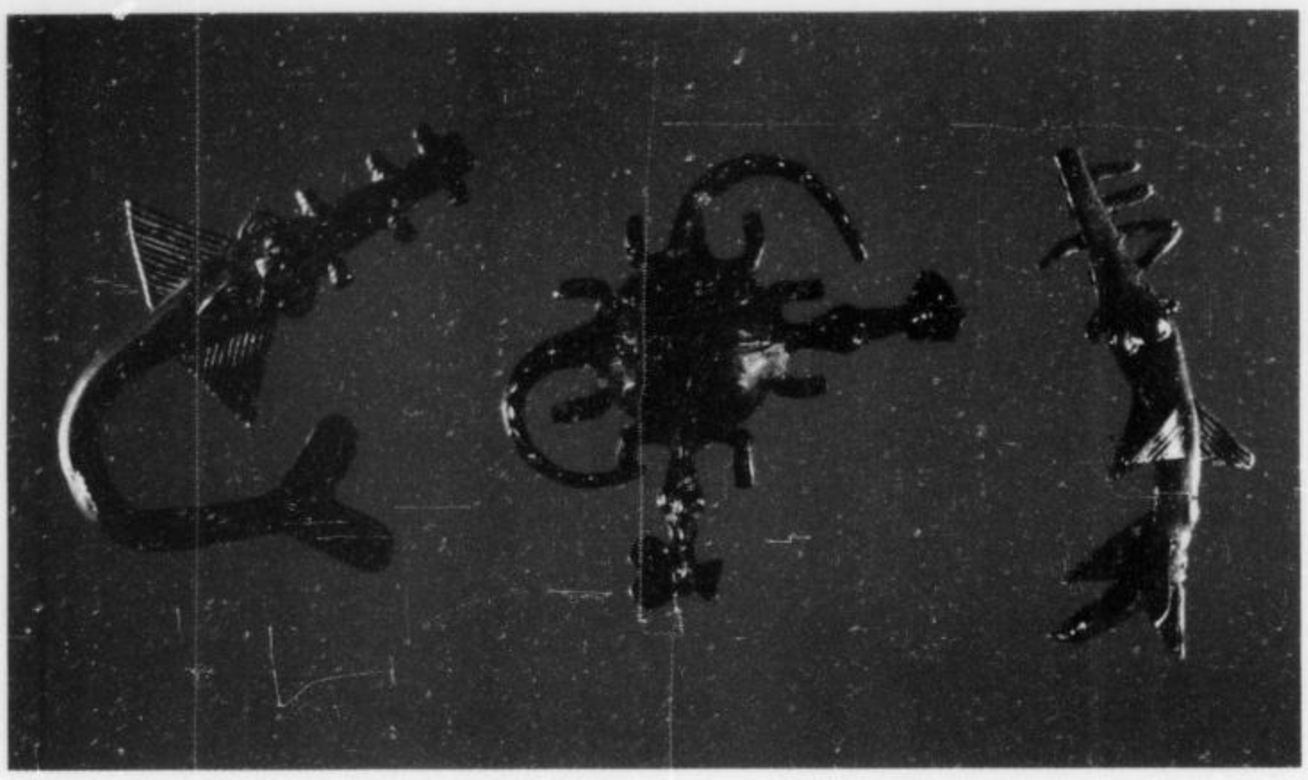
MANY hundreds of well-structured numeration systems were invented in Africa south of the Sahara whose peoples, like those elsewhere in the world, learnt through the ages that it is very difficult to count and calculate if one uses a completely new, different word or symbol for each quantity—that is, for each number. These systems include spoken numeration systems, gesture counting systems, and symbolic systems that use body parts or objects to represent numbers.

The most common way to avoid having to invent completely new words for different numbers has been to compose new number words out of existing ones by using the arithmetical relationships between the numbers concerned. This principle can be seen in many African spoken numeration systems.

In the Makhwa language spoken in northern Mozambique, for example, the words *thanu* (5) and *nloko* (10) are dominant in the composition of number words, and constitute the bases of the system of numeration. The expression for 6 is *thanu na moza* (5 plus 1), and 7 is *thanu na pili*, (5 plus 2). To express 20, people say *miloko mili* (tens two or 10 times 2), and 30 is *miloko miraru* (tens three).

The most common bases in Africa are 10, 5 and 20. Some languages such as Nyungwe, which is spoken in Mozambique, use only base 10. Others like Balante in Guinea-Bissau use 5 and 20. Verbal numeration in the Bété language

Above, Peul drovers in Mali.



Ashanti weights used for weighing gold dust.

of Côte d'Ivoire uses three bases: 5, 10 and 20. Fifty-six, for instance, is expressed as *golosso-ya-kogbo-gbeplo*, that is "20 times two plus 10 (and) 5 (and) 1". The Bambara of Mali and Guinea have a 10-20 system in which the word for 20, *mugan,* means "one person", while the word for 40, *debé,* means "mat", referring to a mat on which husband and wife sleep together—and jointly they have 40 digits.

The Bulanda (West Africa) use 6 as a base so that 7 is expressed as 6 + 1, 8 as 6 + 2, and so on. The Adele count *koro* (6), *koroke* (6 + 1 = 7), *nye* (8) and *nyeki* (8 + 1 = 9). Among the Huku of Uganda the number words for 13, 14, 15 are formed by the addition of 1, 2 or 3 to twelve. Thirteen, for instance, is expressed as *bakumba igimo* (12 plus 1). The decimal alternatives, 10 + 3, 10 + 4 and 10 + 5, were also known.

One advantage of using a low number such as 5 as the basis of a spoken numeration system is that it may facilitate oral or mental calculation where the answer has not been memorized. For instance, 7 + 8 would be (5 + 2) plus (5 + 3). As 2 + 3 = 5, one finds as answer 5 + 5 + 5, 10 + 5, or 5 multiplied by 3.

The duplicative principle

A particular case of the use of addition to compose number words is the situation where both numbers are equal or where one of the two is equal to the other plus one. For instance, the Mbai count from 6 to 9 in the following way: *mutu muta* (3 + 3), *sa do muta* (4 + 3), *soso* (4 + 4), and *sa dio mi* (4 + 5). The Sango of northern Zaire express 7 as *na na-thatu* (4 + 3), 8 as *mnana* (4 + 4) and 9 as *sano na-na* (5 + 4). One possible reason for using the duplicative principle to compose the number words between 6 and 9 is that it may make it easier to do mental arithmetic, in particular duplication operations. For instance, to obtain the double of 7, one has to add, if one has not memorized the answer, 4 + 3 and 4 + 3. As 4 + 3 + 3 = 10, the answer becomes 10 + 4. In sub-Saharan Africa, there is a strong tradition of mental calculation, and oral and mental multiplication often were (and sometimes still are) based on repeated duplication.

In several African languages subtraction, as well as the additive and multiplicative principles, has been used to form number words. In the Yoruba language of Nigeria, for example, 16 is expressed as *eerin din logun* meaning "four until one arrives at twenty". The Luba-Hemba people of Zaire express seven as *habulwa mwanda* ("lacking one until eight"), and nine as *habulwa likumi* ("lacking one until ten").

Spoken numeration systems may vary greatly within relatively small geographic regions. In Guinea-Bissau, for example, the Bijago have a pure decimal system; the Balante use a five-twenty system; the Manjaco use a decimal system with exceptional composite number words such as 6 + 1 for 7 and 8 + 1 for 9; and the Felup use a ten-twenty system in which the duplicative principle is also employed in forms like 7 as 4 + 3 and 8 as 4 + 4.

Some number words are adjectives while others are nouns. In this situation, number word structures may appear that do not correspond directly to an addition, multiplication or subtraction. For instance, in the Tschwa language of central Mozambique 60 is expressed as *thlanu wa makuma ni ginwe,* that is "five times ten plus one more (ten)".

To denote relatively large numbers, completely new words are often used or words that express a relationship with the base of the numeration system. The Bangongo of Zaire say *kama* (100), *lobombo* (1,000), *njuku* (10,000), *lukuli* (100,000) and *losenene* (1,000,000), while the Ziba of Tanzania say *tsikumi* (100), *lukumi* (1,000), and *kukumi* (10,000), the three latter terms being clearly related to *kumi* (10).

Counting by gestures

Gesture counting was common among many African peoples. The Yao of Malawi and Mozambique represent 1, 2, 3 and 4 by pointing with the thumb of their right hand at 1, 2, 3 or 4 extended fingers of their left hand. Five is indicated by making a fist with the left hand. Six, 7, 8 and 9 are indicated by joining 1, 2, 3 or 4 extended fingers of the right hand to the left fist. Ten is represented by raising the fingers of both hands and joining the hands. The Makonde of northern Mozambique start counting on their right hand with the help of the index finger of the left hand. Five is indicated by making a fist with the right hand. For 6 to 9, the representation is symmetrical to that of 1 to 4, that is, right and left hands change roles, with the index finger of the right hand pointing at the fingers of the left. Ten is represented by joining two fists.

The Shambaa of Tanzania and Kenya practise a method of gesture counting that uses the duplicative principle. They indicate 6 by extending the three outer fingers of each hand, spread out; 7 by showing 4 on the right hand and 3 on the left, and 8 by showing 4 on each hand.

To express numbers greater than 10, the

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Sotho of Lesotho employ different individuals to indicate the hundreds, tens and units. To represent 368, for example, the first person raises 3 fingers of the left hand to represent 300, the second one raises the thumb of the right hand to express 6 tens, and the third one raises three fingers of the right hand to express 8 units. This is actually a positional system, since it depends on the position of each man whether he indicates units, tens, hundreds, thousands, and so on.

The use of fingers and hands to count may explain the choice of five and ten as bases for verbal numeration systems. The use of bases may also have been stimulated by practices used to accelerate counting. For instance, Makonde basket makers count the plant strands of the bottom of their *likalala*-baskets by fours instead of counting one by one.

The number 1 as indicated in gesture counting (from top) by the Makonde, the Yao and the Shambaa.

Tally devices

Tally devices were commonly used in Africa south of the Sahara. In Mozambique Chuabo boys use the following counting technique when they are playing football. The two halves of the leaf of a coconut tree obtained after taking off its vein serve as a tally device for each team. The halves are called *mulobuo.* When a team scores a goal, a fold is made in its *mulobuo,* and at the end of the match, the scorer compares the lengths of each one or counts the folds, in order to see who has won.

Among the Tswa, also from Mozambique, trees are used to record the age of children. After the birth of a child a cut is made on a trunk of a tree, and each year a new cut is added until the person is old enough to count for him or herself. Cuts on tally sticks are also used when counting the number of animals in a herd, each cut corresponding to one animal.

Among the Makonde, knotted strings were used. A man who was setting out on an eleven-day journey would tie eleven knots in a string and would say to his wife, "This knot" (touching the first) "is today, when I am starting; tomorrow" (touching the second knot) "I shall be on the road, and I shall be walking the whole of the second and third days, but here" (seizing the fifth knot) "I shall reach the end of the journey. I shall stay there the sixth day, and start for home on the seventh. Do not forget, wife, to undo a knot every day, and on the tenth day you will have to cook food for me; for see, this is the eleventh day when I shall come back." Pregnant women used to tie a knot in a string at each full moon so that they would know when they were due to give birth. In order to register a person's age, two strings were used. A knot was tied in the first string at each full moon. When twelve knots were tied, a knot was tied in a second string to mark the completion of the first year, and so on.

Figures in the sand

A variety of numeration systems exist in Africa that are "written" in one way or another. The eastern Bushongo (Zaire) counted simultaneously by threes and tens. For each three objects, they marked in the sand three short parallel strokes with three fingers of a hand. After completing three groups of three strokes, a longer stroke was marked for the next object to indicate that ten more objects had been counted.

The Fulani or Fulbe, a semi-nomadic pastoral people of Niger and northern Nigeria, place sticks in front of their houses to indicate the number of cows or goats they possess. One hundred animals are represented by two short sticks placed on the ground in the form of a V. Two crossed sticks, X, symbolize 50 animals. Four sticks in a "vertical" position represent 4. Two sticks in a "horizontal" and three in a "vertical" position indicate 23 animals. The following was found in front of the house of a rich cattle owner: VVVVVXII, showing that he had 652 cows.

The Akan peoples (Côte d'Ivoire, Ghana, Togo) used figurines in stone, metal or simply vegetable seeds as coins. The weight of each figurine was agreed to represent the monetary value that corresponded to a certain quantity of gold dust of the same weight. The figurines show animals, knots, stools, sandals, drums and in some cases have diverse geometric forms such as step pyramids, stars or cubes. Many display graphic signs representing numbers. Although in the languages spoken by the Akan peoples only base ten is used, base five is also found on the money weights. The Agni, one group belonging to the Akan people, used a series of units of money weights with a binary structure, each new unit being double the previous one.

FURTHER READING ON NUMBERS

The best general work is undoubtedly

■ **Karl Menninger, *Zahlwort und Ziffer. Eine Kulturgeschichte der Zahl,* Göttingen (1958). English translation by P. Broneer, *Number Words and Number Symbols. A Cultural History of Numbers* (1977).**

See also:

■ **Georges Ifrah, *Histoire universelle des chiffres,* (Paris, 1981).**

■ **"A mathematical mystery tour", *UNESCO Courier,* November 1989.**

The valleys of the Niger

by Jean Devisse

FLOWING some 4,200 kilometres through a drainage basin which covers over a million square kilometres and whose ramifications extend into at least nine countries, the Niger is Africa's third longest river. Although some of the cultures that developed in this vast region are as old as those of the Nile valley they are—undeservedly—little-known. In recent years, however, they have begun to be studied scientifically, and archaeological excavations have brought to light new information that has enabled scholars to reconstruct part of the rich past that slumbers here in the earth of Africa.

The Africans of the Niger basin, like people in many other parts of the world, wanted to make sure their ancestors' remains were respected. Like the tombs of the Etruscans, the kurgans of Ukraine, the mastabas of Egypt and the vast cemeteries of Napata in the Sudan, these burial places faithfully conserve the memory of the past.

The remains of houses of unbaked earth that were built hundreds and in some cases thousands of years ago also contain keys that can help to unlock the past. Large quantities of pottery, ceramics and metal objects will provide eloquent testimony, as long as they are treated carefully and scientifically.

Archaeological and historical research is a late-comer to this part of the world. Much has been achieved in the last twenty years, but an enormous amount of work still needs to be done. In addition to funding, such research requires above all boundless patience and respect on the part of scholars. It is imperative that archaeological investigation should not be jeopardized by wanton violation of the ancient tombs and that the stratigraphy of village and urban ruins should not be destroyed by profit-seekers hunting for trophies or artefacts to sell on the market.

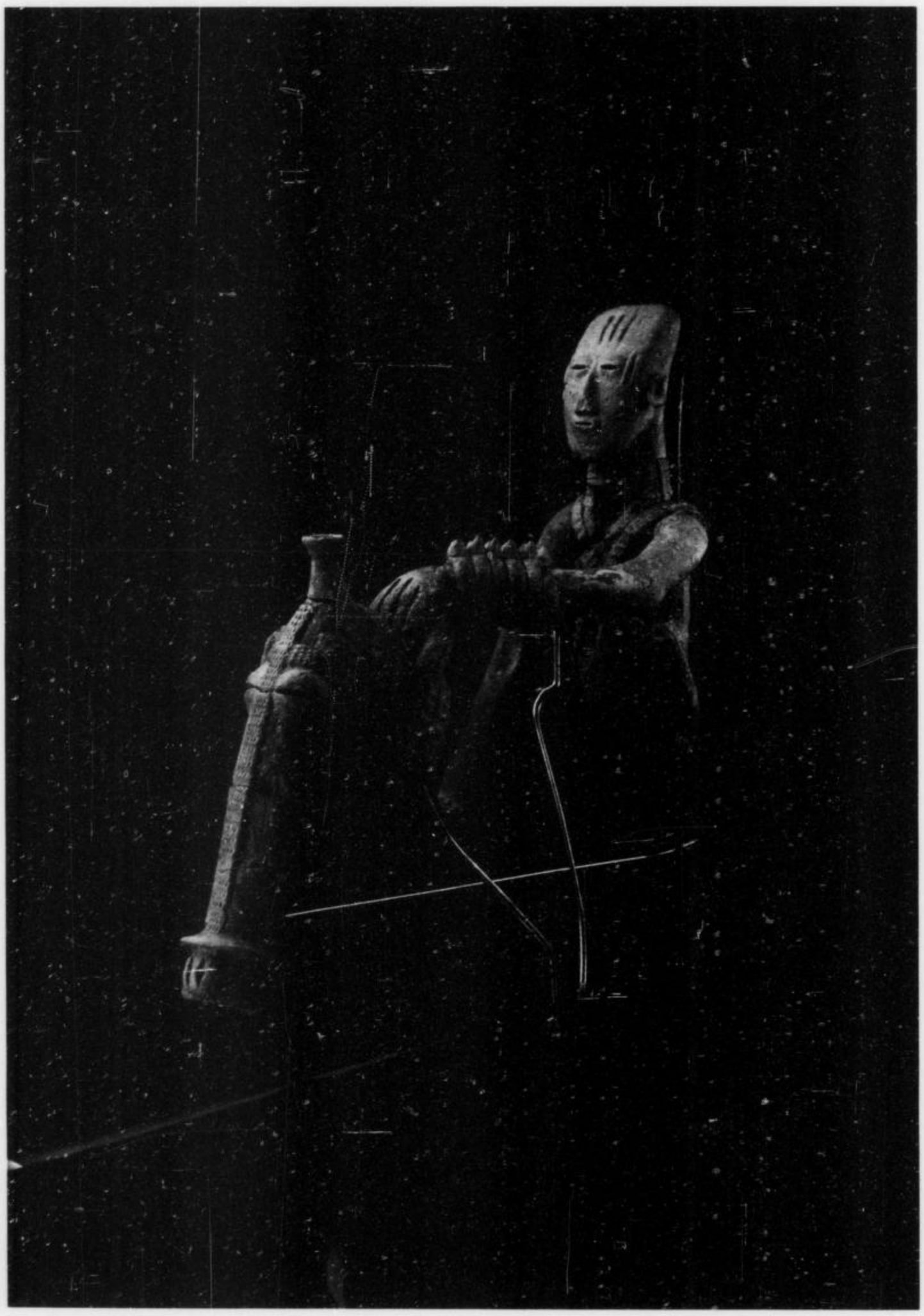
This does not mean clamping down on the trade in works of art by pitting researchers against dealers, but trying to make people understand, recognize and respect the priorities of research. What is at stake is the opportunity to discover intact precious evidence of the Niger basin's past.

In the last three years, a team of French and African researchers has been preparing a major travelling exhibition to present this immensely rich heritage which is over 5,000 years old. The exhibition can be seen in Paris, its first port of call, from October 1993 until January 1994.

It is divided into ten "sequences", the themes of which are described below. First of all there is a brief visual introduction, including maps and chronological tables, to the countries concerned, and an explanation of the approach adopted by the organizers. Then visitors are taken along the course of the river, from its sources to its delta.

▶ 1 - The *valleys of the upper Niger* were the cradle of a great power that flourished between the thirteenth and seventeenth centuries—that of Mali—and an area where kola, gold and rice were produced in ancient times.

▶ 2 - *Iron*, which played a vital part in the growth and hierarchical development of societies in the Niger basin, appeared as early as the second half of the last millennium of the pre-Christian era in Nigeria and perhaps a thousand years earlier in



Large figure of a horseman (between 3rd and 10th centuries) originating from Bura (Niger).

Ténéré. It was produced and worked almost everywhere by the beginning of the Christian era.

▶ 3 - The *inland delta* is a vast area to which floods bring an annual increment of silt. Just as ancient Egypt was described as "a gift of the Nile", this vast inundation is a "gift of the Niger", but it did not give rise to a centralizing power such as that which developed in Egypt as early as the fifth millennium B.C. On the contrary, the high waters isolated groups of people who took refuge on small islands known as *togué*. The remains of an ancient settlement, Jenné Jeno, have been found and partially excavated on some of the most remarkable *togué* near the city of Jenné in Mali. Between eight and nine centuries older than the existing city, Jenné Jeno has been included on UNESCO's World Heritage List. The delta has been inhabited for at least 5,000 years, and only a fraction of the vestiges of its past have yet been unearthed. It is the area most threatened by looting.

▶ 4 - It has often been thought and written that *Sudanese architecture,* as displayed in many mosques old and new, did not appear until the fourteenth century. However, its roots go back much further.

▶ 5 - *Gold,* which was produced, traded and minted into coins "in the north", was considered locally to be less precious than copper.

▶ 6 - Northwards, beyond the ridge of *Wagadu* (the ancient empire of Ghana), lay the trade routes of Mauritania; to the west was the basin of the Senegal River. Major discoveries from Kumbi Saleh, the capital of Wagadu, are presented, as well as a model of the splendid mosque (10th-15th centuries).

▶ 7 - Some seven or eight thousand years ago, a huge network of rivers flowed down from the north to the left bank of the Niger between the Tropic of Cancer and the Niger Bend. Today it no longer exists, but traces of human activity have survived in what are now *dry valleys.* One extraordinary example is a tomb at Iwelen (Niger), which dates from the middle of the eighth century A.D.

Bronze statuette of a horseman (between 15th and 18th centuries) from the ancient kingdom of Benin (Nigeria).

▶ 8 - Perhaps the most unexpected and spectacular of the ten sequences is that devoted to *funerary practices.* It features various forms of inhumation in earthenware jars (Mali, Burkina Faso), funerary steles, mass graves (Tellem du Mali) and a remarkable "village of the dead" unearthed in Niger.

▶ 9 - The *copper* sequence follows those devoted to gold and iron. The quality and complexity of copper-working techniques as well as the ramifications of the copper market are illustrated.

▶ 10 - Exceptional coverage is given to the *valleys of the lower Niger* in Nigeria, the cradle of Nok art (remarkable both for its longevity—it was produced for more than a thousand years—and for its diversity) and the sophisticated art of Ife and Benin. Also displayed are treasures discovered during excavations near Igbo Ukwu, which are quite different from anything previously discovered.

The exhibition ends in a music room where visitors can admire the landscapes, art and current activities of the Niger basin while listening to African music.

The exhibition is co-organized by Burkina Faso, France, Guinea, Mali, Mauritania, Niger and Nigeria, with an important contribution from the Netherlands. It will travel from Paris to other cities beginning with Leiden (the Netherlands) and probably Philadelphia (United States) in spring and summer 1994. It will then be shown in Bamako (Mali) from October to December 1994, Ouagadougou (Burkina Faso) from January to March 1995, Lagos (Nigeria) from April to June 1995, Niamey (Niger) from July to September 1995, Nouakchott (Mauritania) from October to December 1995 and Conakry (Guinea) from January to March 1996.

A richly illustrated book describes each sequence of the exhibition and sets it in its context, presents the findings of the past twenty years of research, and outlines the new directions being taken by current investigations. The exhibition is to be presented in condensed form on panels that will be sent to each of the co-organizing countries, so that it can reach schoolchildren and rural populations far from the capitals where it will be displayed. ■

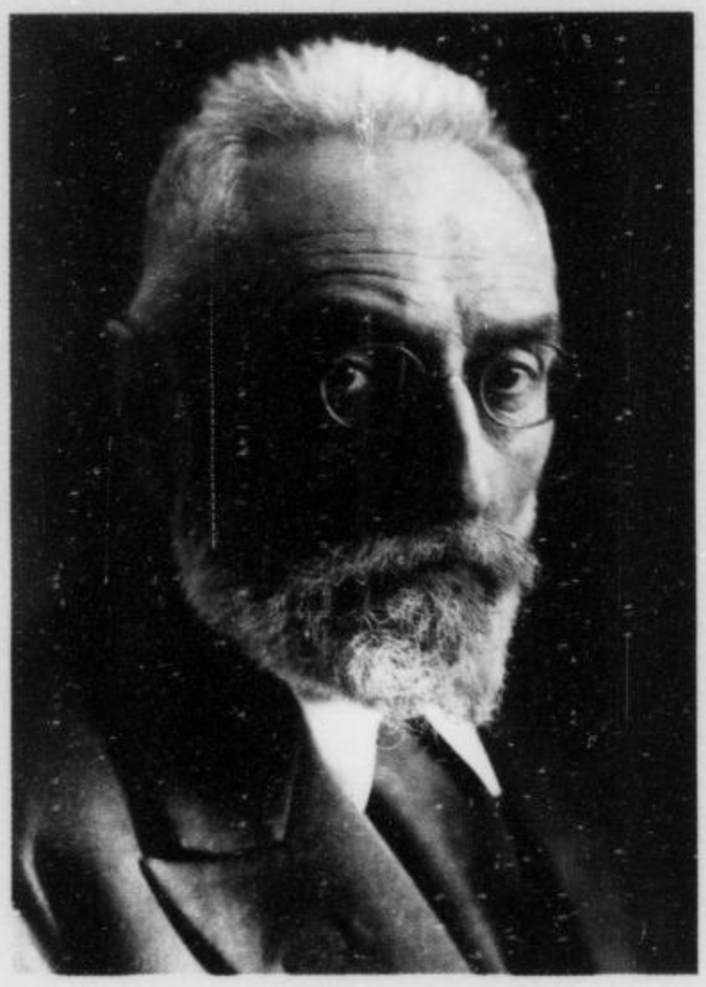
Head of an anthropomorphic terra-cotta figure from Jemaa (Nigeria).

JEAN DEVISSE, of France, is professor emeritus of African history at the University of Paris I and rapporteur of the International Scientific Committee for the publication of UNESCO's *General History of Africa.* He is commissioner-general of the exhibition on the Niger basin described in the present article.

In Paris the exhibition (entitled *Vallées du Niger*) can be seen from 14 October 1993 to 10 January 1994 at the Musée National des Arts d'Afrique et d'Océanie (National Museum of African and Oceanic Arts), 293 Avenue Daumesnil, 75012 (tel: 44 74 84 80).

Miguel de Unamuno on the future

In 1933, the International Institute of Intellectual Co-operation organized a series of talks in Madrid in which Miguel de Unamuno gave his views on the future of culture. Professor of Greek and later rector of Salamanca university, philosopher, poet, playwright and a lifelong opponent of bigotry and dogmatism, Unamuno was one of the most influential Spanish thinkers of his time. When he gave the talks (between 3 and 7 May) he was 68 years old.



Miguel de Unamuno y Jugo (1864-1936).

I must admit that after over forty years as a teacher, I have reached the stage where I don't know what culture is. What I do know is that I find it rather burdensome. Instead of making a series of formal observations, I am going to treat you to an outpouring of personal impressions. I'm feeling a little tired and so, I think, is most of civilized humanity at this moment. What we need is not so much peace as rest, because there is such a thing as peace without rest and a dreadful thing it is!

In economic terms, everyone knows that there is a disparity between production and consumption. We have consumed for the sake of production rather than produced for the sake of consumption, and the same thing can be said of intellectual and spiritual life. Most people cannot keep up with today's intellectual output. People are thinking too fast. That is a very serious matter. Pindar said that Tantalus had been punished for not being able to digest happiness and joy. Perhaps many people suffer today because they cannot digest truths and, even more serious, cannot digest the truth. It is very unpleasant to be incapable of digesting happiness—swallowing it is something different. But it is even more serious not to be able to digest and swallow the truth.

In this very place I met one of my friends, a highly cultivated, well-read man who has travelled widely but never writes anything. When asked, "Why don't you produce anything?" he answers, "I produce consumption."

Of course, in consuming culture we produce it as well. It is perhaps more difficult to consume than to produce. It is more difficult to listen than to speak, more difficult to read than to write, far more difficult. Most of the writers I know, unfortunately, cannot read. Digestion is very difficult.

The question of the future of culture, its goal and purpose, which will be, perhaps, to achieve the spiritual unity of humanity, has not been raised. Speaking for myself, I never achieve my own unity. I always carry within me a people fighting a civil war. One of the things that makes me suffer the most, when I am engaged in a discussion with another person, is to see that person defend himself when he is unfamiliar with the grounds for his argument and I know them better than he does. At present most people, here at any rate, are living in anguish. But I do not want to talk about current affairs because they are above or below what we are dealing with here.

Of course, the cultural point of view in my opinion is a matter of religion. I am going to make a digression. In the past people said, "Long live Christ the King" to show that they were monarchists. The other day I was talking about Velasquez, to whom I dedicated a poem. His painting of Christ says something, it tells you quite clearly, "My republic is not of this world, it is of another world."

Yes, education is a national issue, but it is also a danger. When I look at all these books about how to teach I have the impression that children are being used as fodder for testing, that the aim is not to educate them but to bring them up as if they were frogs or guinea pigs for psychologists. This is dreadful. Poor young people! What they have to go through because of these books! They are trained like performing animals!

"Is teaching an unnatural function?" Socrates was not a teacher, but a vagabond. He wandered the streets of Athens talking to everyone. That's what culture is. Here in Spain there is a deep-rooted popular culture forged by tradition in what is the true people's university of Spain, the cafés. This culture is more universal than the other one. The other one is international rather than universal, which is not the same thing. What is most universal is what is most individual, and the people in our cafés and countryside are profoundly individual.

I believe that to defend the universal you have to stand up for the individual. Mr. Severi has talked about the national character that all the sciences have. Science is naturally a language because even mathematical formulas are written in Spanish, French, English and German. Always. I also believe that the mind makes language and that words are what make us. Even philosophy makes language. Hegel is the German language. Cartesianism is the French language speaking, scholasticism is thinking in dead Latin. In Spain there is also a kind of fluid philosophy. It is not systematic. It is in the language of the people. In Spain there have never, or almost never, been philosophical systems. That does not mean that there have never been philosophers.

In the foreword to the Baedeker guide to Spain it says that we Spaniards are touchy

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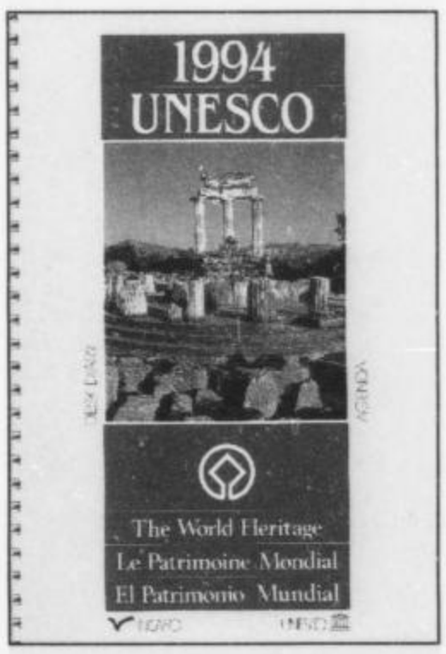

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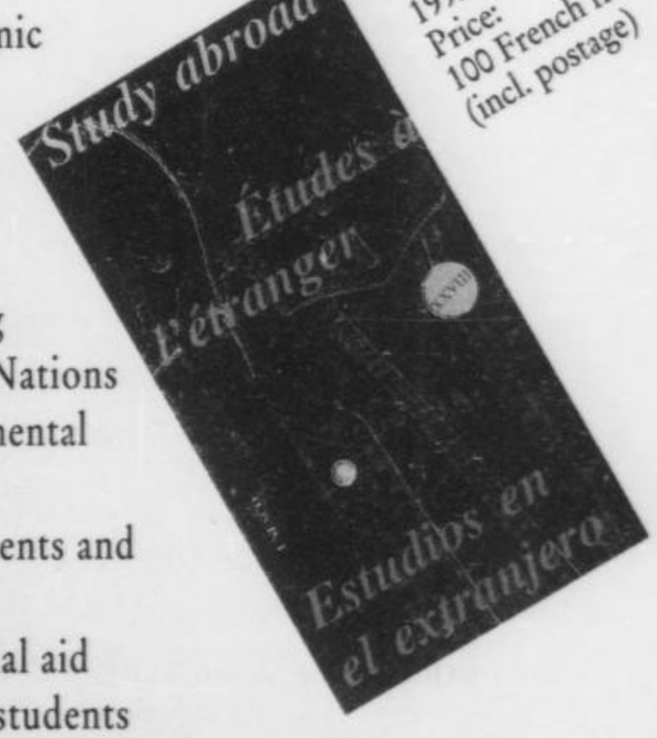

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I V E S

of culture

Text selected and presented by Edgardo Canton

and easily offended. There's more to it than that! In Spain, when we have the army we are anti-militarist. When there was the clergy, there was anti-clericalism. I have no doubt that our children and grandchildren will be anti-teacher. People talk about tyranny. Well that is a form of tyranny. I am a teacher but I naturally resisted falling into a professional rut because, instead of working and having my students work on other people's poems, I have a weakness—I write poetry myself. It is my weakness to be a direct producer. A kind of civil war goes on inside me. Anyone who studies literature always ends up hating what he studies, always. I've seen it happen. Whenever people talk about individuals or personalities I am accused of being an individualist because I am an anarchist. To me individuality is a kind of container and personality is the content. It is possible to have a strong individuality without much of a personality. I know people in Spain with a very strong individuality, but they are almost all the same. Their minds are skin and bone. They are like crayfish and lobster. They have bones on the outside and and flesh on the inside. But there are other minds, even here on the peninsula, who are more like octopuses and invertebrates. Some of them have very hard shells. They are very strong on the outside. But there are also people who are soft and swallow the lobster or crayfish whole with its shell, digesting it without chewing.

There is a nationalist international. This is one of the most dangerous things in existence, because it is not universal!

The most universal is the most individual. All my life I have fought to defend my own individuality and I thought that in doing so I was also standing up for the freedom and the individuality of my country, Spain, which I bear inside myself. At times I have said, with the modesty so typical of me [*laughter*], that not only am I a son of Spain, I am one of its fathers as well! Spain is also my mother, but it's my daughter too. Sometimes one needs solitude. Here we are together and I shall look back on this talk with pleasure. I have recognized people, but I shall go back home to see if I can still recognize myself. Let me tell you a little anecdote. One day I was in Barcelona, where I went to see the director of the asylum, who is a friend of mine.

He said to me, "One of my inmates knows you're here. He wants to meet you".

I was introduced to the madman. He was calm; he was perfectly all right.

"Mr. Unamuno?" he asked.

"The very same!"

"The real one? Not the one who lives on paper and in the press?"

"Yes."

But afterwards I had second thoughts and wondered if I was the real one. I wondered if I was the person I knew or the one other people knew, myself or the historic man, who is not made of flesh and blood.

In Spain we've managed to turn a fictional character, Don Quixote, into a national hero. Did he exist? He does exist.

We must be wary of education, and especially of national education, of the clerisy of the state. I, who am an educational functionary, an administrator, humble though I may be—as an administrator, of course [*laughter*]—I see the danger of wanting to train young people in one way or another. What can be done about it? We cannot let them teach themselves. And yet they would do the job very well if they were left to themselves. I repeat, the danger of teaching is the fatigue I mentioned earlier, and the fatigue is partly a result of that. People's minds are overloaded. Poor children! I have known children who were very clever until the age of seven. After that their intelligence stopped developing. . . .

Let's get back to what I was saying about the danger of fatigue. It stems from a certain kind of education, from teaching. There are two things I cannot stand: pedagogy and sociology. The former must be replaced by art and the latter by history.

Another time I shall have an opportunity to return to some of these ideas in greater detail. For the moment we are here to get to know each other. The Greek oracle said, "Know thyself". Why? What I say is, "Know others, not yourself". I do not think anyone can know his or her self, fortunately. We are here to see each other and get to know each other, to feel a certain human warmth, to experience something more than ideas, perhaps to see our different ways of approaching life. If you foreigners leave here knowing a little more about our Spain, this old Spain where people, including myself, believe a renewal is under way, we should thank you. I am Spanish, and profoundly so. You are in a country which, I think, has a great culture, a profound culture. Those who cannot read or write may be even more cultured than the rest. They have long centuries in their souls, not only thought and faith. Faith is very difficult to define. Of course, if it is defined it ceases to be faith. A god who is defined is no longer a god. Faith is necessary. Faith in what? I don't know.

In the Basque country where I was born there was a bigoted old woman who often went to mass. Because of my interest in these matters I once asked her:

"Tell me, madame, what do you believe comes after death?"

"After death?" she replied. "I haven't had time to think about that kind of thing".

Please excuse me for rambling on; I do believe these ideas can shed some light on the subject. At the same time I think this is a subject on which not too much light should be shed. Too much light is not a good thing. You solve one problem and twenty or thirty new ones appear in its place. You have to work. This quotation from an old Italian poet comes to mind: "*Meglio oprando obliar senza indagarlo questo enorme mister de l'Universo*"—We are better off trying to forget the great mystery of the universe. The trouble is that I cannot resign myself to forgetting this great mystery. To get back to culture: I repeat that at the age of seventy and after forty years of teaching I have reached the point where I do not know what it is. I hope my own people, your peoples, may have a few years not only of peace, but of rest, rest during which they will be able to sleep and digest truths and the truth. Perhaps that is the hardest lesson in the life of the world. ■

UNESCO'S PROGRAMME FOR 1994-1995

SOLIDARITY

UNITED WE STAND...

Mounting intolerance and inequality are dividing the world. In response, Federico Mayor, Director-General of UNESCO, calls for a sustainable global approach, based on the values of solidarity and sharing. It is in this direction that the Organization will be moving in 1994-1995.

ALTHOUGH huge threatening clouds hang over the dawn of the third millennium, humanity has at its disposal the means to make the changes required. Though yearning for equality encounters inexorably growing disparities, and strivings towards fraternity founder upon individual self-interest, we can win through if only we are clear-sighted, resolute and bold enough to effect a radical change of course.

More wars are being fought today than at any time in the last fifty years. In the past decade, people fleeing death, destruction, and even deliberate policies of plunder and extermination, have swollen the ranks of the world's refugees from ten to twenty million. At the same time, there have never been so many negotiated solutions and processes of reconciliation, under the aegis of the United Nations in particular.

Although the danger of a nuclear holocaust may have virtually disappeared, more and more countries possess nuclear weapons, and new tensions are developing in a number of places. For all its harmful effects, the polarization of international relations brought about by the East-West conflict did at least keep in check the war-like impulses of those who tried to escape from its grip. The very subjection imposed by the totalitarian regimes served to restrain the hatreds and fanaticism that, with the collapse of those regimes, are now bursting their banks. Differences, cultural, racial and ethnic, lead more and more often to a hostility that may result in exclusion or even, in extreme cases, extermination.

At the same time, the disparity in the resources available to people to provide for their needs is growing: superabundant for a few, they are, for an ever greater number, increasingly, pathetically inadequate. While global figures may, for instance, show a steady growth in living standards and school attendance or a fall in mortality rates, such overall improvements conceal a widening gap between the extremes.

About 1.3 billion people in the world today live below the poverty line, with no chance of feeding themselves adequately. They include nearly all the 30,000 children who die every day directly or indirectly from malnutrition, most of the one billion people who cannot read or write and almost all the 300 million children who are deprived of schooling. On the other hand, the income of the richest fifth of the world's population is 150 times greater than that of the poorest fifth, and this disparity has actually doubled in the last thirty years.

The present pattern of development is all awry. Even as the North-South gap widens, international trade is organized in such a way that it deprives developing countries of $500 billion a year—ten times more than they receive in foreign aid. Since the mid-eighties, debt repayments by the poor countries have exceeded the amounts they receive from the rich lender-countries, and the difference is increasing every year. Inequality is growing in the developed countries too. The existence of "two nations" within almost every country is becoming as inescapable a fact as the existence, in the world as a whole, of "two-track" societies.

A further harmful effect of the present pattern of development is that it depends on overexploitation of natural resources and at the same time causes damage to those resources it does not exhaust. Deforestation, the excessive depletion of the ozone layer and the steady erosion of our bio-genetic heritage prove that our ways of living and producing have now brought us up against a physical threshold.

WALLS OF ILLUSION

This threshold is all the more real in that population growth is increasing our impact on the environment. The world's popula-

AND SHARING

tion is growing by 254,000 a day. At this rate, by the year 2030, it will have reached at least ten billion, compared with just under six billion today. About 95 per cent of this increase could be in developing countries, with the highest growth rates in the poorest of them. Along with all their other problems, these countries would thus have to cope with increasing pressure of population on an increasingly despoiled environment. How could the population of these countries agree to stay put?

No wall would be high enough to stop them emigrating en masse to the sparsely populated, fabulously rich countries whose streets they imagine to be paved with gold.

It is easy to see how such influxes of immigrants could fuel reactions of xenophobia and exclusion, if those reactions persist.

I have used the words "would" and "could" because I am convinced that we will act in time, using our immense talents to prevent such developments and provide each people with the means to become the master of its fate.

Just as it is hard to see the wood for the trees, so the Berlin Wall concealed the real priorities, the hidden threats, and the new solutions. Before the Wall fell, the East-West dichotomy hid many facts from sight, brought to a standstill all thinking that did not proceed therefrom, shaped patterns of development and governance and exercised a disproportionate influence on international relations. We lived in a sort of blind tranquillity, where thought was benumbed and action to face the great challenges of our time was paralysed.

So there is no call for nostalgia. The collapse of the totalitarian regimes has created openings for a freedom which, though fragile, is at last attainable. With the increase in the number, scale and speed of the flows of people, goods, capital, ideas, knowledge and information, the unification of the world (the famous "global village") seems irreversible, yet the world is becoming more and more divided as inequalities grow and differences—although they contain the answers to a good many of our problems—tend to be seen as threats. United but not uniform. The irreversible process of globalization now underway is incompatible with a narrow attitude of self-preservation. We have no choice but to organize that process equitably.

A NEW ATTITUDE

It has to start with a new attitude towards others. The differences between us must be accepted, and we must show tolerance for others and respect for their freedom and dignity. In pursuance of new approaches to development, poverty must be combatted by practising the virtues of solidarity, sharing and the sense of fraternity which, according to André Malraux, is alone capable of putting an end to inequality. To think and act in the short term and at the local, or national or even regional levels is becoming ludicrous. While action must continue to be adapted to local situations, both its basis and its effects must be seen in the context of a long-term, general, global vision.

The transition from an age-old culture of war to a culture of peace requires the participation of all, their weapons being common objectives and agreement on essentials. The challenges of the past were met with force; those of the future will be met with intelligence. This transition calls for a change of outlook, combining intellectual adventurousness with perseverance in the way of sustainable action. How many failures are the result of short-lived convictions, of meeting violence with violence! Whatever the affront, non-violence must be the universal basis of response. The complexity of reality must also be accepted: simplification is neither rigorous nor useful, and a pluridisciplinary approach is the only way forward to precise understanding and effective action.

With this in mind, the activities that UNESCO is to carry out in 1994-1995 will have three main objectives: the promotion of a culture of peace and tolerance; the establishment of a type of development that has human beings as both its agents and its beneficiaries; and the preservation of the environment and the rational management of resources. These activities will be particularly aimed at populations and groups that are in distress: women, the least developed countries and Africa.

To achieve these aims, UNESCO has neither battalions nor substantial financial resources at its disposal. The means it employs are of a different kind: building up the intellectual and moral solidarity of mankind so as—adapting the words of UNESCO's Constitution—to construct the defences of peace in the minds of men. Its purpose is indeed to combine and conjoin the creative capacities of all the world's educators, scientists, researchers, artists and journalists, to pave the way to a world where everyone can at last learn to coexist and share. ■

UNESCO: THE STRUCTURE

UNESCO comprises three bodies: the General Conference of Member States, the Executive Board and the Secretariat.

The General Conference, which is sovereign, "shall determine the policies and main line of work of the Organization". Meeting usually in the latter half of every second year, the representatives of all Member States—currently 175—following the principle of one vote per country, finalize the Organization's programmes and the amount and breakdown of its "regular budget", decide on Conventions and Recommendations, elect members of the Executive Board and, as is the case this year, appoint the Director-General.

The Executive Board, representing all the Member States between sessions of the General Conference, has 51 members who meet twice yearly to prepare the agenda of the General Conference and recommendations to be submitted to it. The Board is, above all, responsible for the execution of the programme adopted by the Conference, and can take any measures necessary to this effect.

The Secretariat is UNESCO's executive branch. Under the authority of the Director-General, who is elected for a period of six years, the staff implements the adopted programme and provides the General Conference and the Executive Board with all necessary elements for the successful accomplishment of their work. ■

SOLIDARITY AND SHARING

EDUCATION

Access, quality and relevance are the key words in UNESCO's education programmes for the coming biennium

REACHING THE MISSING MILLIONS

by Cilla Ungerth Jolis

IN Croatia, 200,000 children displaced by civil strife have no access to schooling. In Somalia, where war has destroyed virtually all schools, 99 per cent of boys and girls are deprived of education. In Cambodia, most of the country's young are ill prepared to help reconstruct their country because they cannot even write their names. In Mali, 68 per cent of men and women are illiterate. In many other countries, education is underfunded, ill-equipped and given low priority.

When Victor Ordoñez, UNESCO's director for basic education, prepared the draft programme for 1994-1995, he faced the following dilemma: on the one hand, there are some 948 million illiterate adults in the world and almost 130 million children with no schooling; and on the other, UNESCO's budget is lower than that of a medium-sized university in an industrialized country. Under such conditions, what can UNESCO do to make a real difference?

A CATALYST

The new programme, which concentrates on a few large-impact actions, has two main goals: to provide basic education to those children and adults who have no access to it, while at the same time boosting its quality and relevance. One approach is to act as a catalyst. Thus Member States will be able to draw largely on the report to be submitted at the end of 1995 by the International Commission on Education for the 21st Century, headed by Jacques Delors.

"Even if our budget is a drop in the ocean, UNESCO can maximize its impact by helping governments to act," says Mr. Ordoñez. "They are, after all, responsible for the education of their citizens." A third of the budget (almost $200 million) has been earmarked for advisory services and other activities to help Member States frame policies and programmes, especially to assist eastern European and central Asian countries rebuild their education systems.

Another emphasis is closer co-operation with a range of partners in the follow-up to the World Conference on Education for All held in 1990. At this gathering of governments, international agencies, professional bodies and non-governmental organizations, 155 governments committed themselves to education for all before the year 2000.

One example of inter-agency collaboration is a new project focused on nine of the world's most populous countries: Bangladesh, Brazil, China, Egypt, Mexico, India, Indonesia, Nigeria and Pakistan, which account for half the world's population, 72 per cent of the world's illiterates and over half of out-of-school young people. "By targeting our action on these countries," says Mr. Ordoñez, "we can make a spectacular change in the world situation." As part of the project, a Summit of leaders of these countries will be organized by UNESCO and other UN agencies in December.

Other target groups are the least developed countries in Africa, the Arab states and east Asia. "We will take an especially hard look at legislation, policies and programmes which help or hinder education for women and girls," says Mr. Ordoñez. For example, a task force of women will be set up to plot action in support of basic education in this area. Other target groups are young children among refugees or with special learning needs, young people in urban slums, and cultural minorities and remote populations.

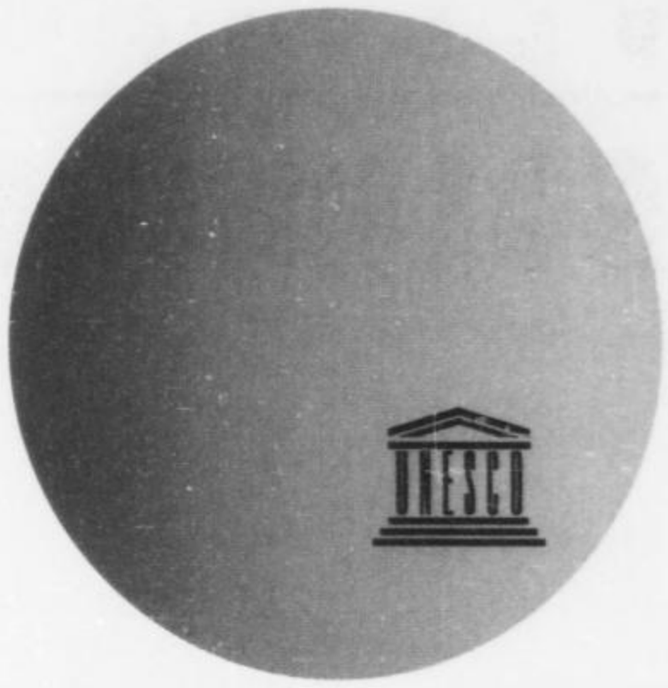
The new "Scheme of Humanitarian Assistance for Refugee Education" (SHARE) responds to the needs of the 88 per cent of refugee children who receive no schooling. It goes beyond the urgent but short-term goal of providing shelter, food and medicines, to develop a coherent policy of refugee education in co-operation with local and national authorities. After initial experiences in Cambodia, Somalia and Afghanistan, SHARE activities are now underway in Slovenia and Croatia.

But placing more children in school and more adults in literacy classes does little good if what they learn there is irrelevant to their lives. That is why UNESCO is also focusing on the content and process of basic education, with stress on boosting the effectiveness of teachers and instructors, school management, the measurement of learning outcomes, and the development of a prototype curriculum for the first four years of primary education. "Because too few children get more than four years' schooling," says Mr. Ordoñez, "it is crucial that they learn something essential there to survive in life. The three R's, yes, but also health, nutrition and the preservation of the environment."

So despite the great need and limited resources, UNESCO is, in the words of Director-General Federico Mayor, "deeply committed to making the right to education an everyday reality, not a remote promise." ■

1994-1995:

This dossier presents the draft programme and budget for 1994-1995 that has been drawn up for submission to the 27th session of UNESCO's General Conference (15 October-16 November 1993). It has been prepared by the staff of the monthly magazine *UNESCO Sources*, whose editor-in-chief is René Lefort.



UNESCO IN ACTION

SCIENCE

The quest for sustainable development is the mainspring of UNESCO's scientific activities

IN SEARCH OF THE GRAIL

by Sue Williams

IN the wake of the UN Conference on Environment and Development held at Rio de Janeiro in 1992, sustainable development has become a new Holy Grail, and "capacity building"—strengthening human resources, particularly in developing nations—has been deemed one of the keys to fulfilling the quest. It is also the foundation of UNESCO's scientific programmes for the 1994-1995 biennium.

"The human element is the most important factor, both as a means of achieving sustainable development and as its main beneficiary," says Adnan Badran, UNESCO's Assistant Director-General for science. "We therefore need to get whole populations involved and provide countries with the knowledge and expertise they require to carry out research and implement projects that will bring about such sustainable development."

UNESCO's science programmes for 1994-1995, which in many ways served as a forerunner to the Earth Summit and which were roundly endorsed by the participants in the Rio meeting, have consequently put the emphasis on education, specialist training and research. Workshops, scholarships, exchange programmes, research grants and specially devised computer modules will thus enable thousands of biologists, chemists, geologists, hydrologists, marine scientists, ecologists and technicians to be trained.

At the same time the science programmes have fine-tuned their research to the goals and priorities of Agenda 21, the plan of action adopted at Rio, for which they are particularly well suited. The Man and the Biosphere (MAB) programme's network of 311 biosphere reserves in all types of ecosystems around the world, for example, provides a ready-made global laboratory for the study and monitoring of biodiversity. The "Diversitas" programme has been set up to this end, covering terrestrial, freshwater, marine and coastal environments and all living things, from whales to microbes. The biosphere reserves could also provide logistic support for research by the International Hydrological Programme (IHP) which seeks to improve understanding of the water cycle and management of the planet's precious water resources. Those in coastal areas could provide precious data for the work of the Intergovernmental Oceanographic Commission (IOC) in monitoring global change. For its part the International Geological Correlation Programme (IGCP) will be geared towards better identification of mineral resources.

Another characteristic of the workplan for 1994-1995 is the emphasis on an interdisciplinary and multi-sectoral approach. "The environment must not be treated in isolation," explains Gisbert Glaser, co-ordinator of UNESCO's environmental programmes. "It is inextricably linked to a range of other domains, and our work must concentrate on these interrelations."

The "Environment and population education and information for human development" project is a good example of the new direction being taken. "The overall aim is to improve education and information on subjects which are too often treated as separate issues," says Glaser. The $2.1 million project is a combined effort by the science, social science and education sectors with other UN agencies, and will see the development of scientifically sound teaching materials as well as information for decision-makers and the media, the training of experts, and the provision of technical support for reshaping education systems and training programmes.

GREEN ENGINEERS

A major push will also be made in basic and engineering sciences—to improve university teaching and promote research in these fields. "It was said clearly in Rio that engineering sciences should incorporate environmentally friendly components," says Mr. Badran. "Engineers shape our landscapes and thus have an important impact on the environment. In the past, they have not been concerned about this impact—they have not been concerned about such details as the level of carbon that their machines have spewed into the atmosphere or the effect of chlorofluorocarbons (CFCs) on the ozone level—and this must change." The University-Industry-Science Partnership (UNISPAR) project well illustrates UNESCO's aims in this direction.

UNESCO will also reinforce its support for renewable energy research and networks of solar energy centres in the Mediterranean countries, Africa, Asia and Latin America.

"Strength through union" is how new MAB Director Pierre Lasserre describes the programme's guiding principle for the coming biennium. It would also serve well as the leitmotiv for the rest of UNESCO's science sector. ■

SOLIDARITY AND SHARING

SOCIAL SCIENCES

Ending the isolation of researchers in the human sciences is the goal of a new programme mounted by the Social Science Sector

BUILDING BRIDGES

by Nicolas Michaux

ONE major subject left off the agenda of the Rio Summit on Environment and Development was the extremely sensitive issue of population. However the topic is set to come storming back. Another big world conference is to be held in Cairo in 1994 specifically on this question which presents such a serious challenge to our future.

UNESCO starts off better prepared for it perhaps than other international institutions since it is the only organization in the United Nations system with a social science sector.

Over the next two years, studies that have already been begun on international migrations will be continued and others including studies designed to improve birth control policies will be launched. In particular, fertility rates will be examined in regions such as sub-Saharan Africa and the Caribbean.

FAMILY AND EDUCATION

1994 will also be the International Year of the Family (an important meeting is scheduled to be held in Malta) during which UNESCO will offer states technical assistance for drawing up family policies following on from the studies that have been carried out for several years with this in mind. UNESCO is particularly concerned to develop studies on the family and education. In 1995 it will contribute to the United Nations Year for Tolerance and to the World Summit for Social Development. It will also pursue a variety of other activities ranging from youth to questions of ethics in research on the human genome.

In all these fields, as one of the officials responsible for the sector, Souleyman Baldé, points out, "UNESCO does not do, but gets things done". In other words, in close co-operation with non-governmental organizations, states, networks of researchers and other bodies, it promotes studies on topics which it considers crucial and helps specialists to compare their findings and to make the results known.

In response to the appeal for peace launched by the Secretary-General of the United Nations, Mr. Boutros Boutros-Ghali, and to the requests of countries that are struggling to emerge from war, UNESCO is also working for the consolidation of peace and democracy. This involves a series of activities including helping demobilized soldiers to return to civilian life, the preparation of elections, and providing an introduction to parliamentary life and the concept of the public good in countries that in some cases have no real experience of democracy.

But the main objective of the Social Science Sector is "to give structural solidity to its programme", in the words of Ali Kazancigil, who is in charge of UNESCO's activities to promote the international development of social and human sciences, by establishing international research programmes on some of the major topics of the day. However astonishing it may seem when it is universally recognized that the major challenges of our time are global and interdisciplinary by nature, specialists in the human sciences and the research they carry out are, according to him, "remarkably isolated". The bipolarization of the world was a great obstacle to joint research under the auspices of an international organization such as UNESCO.

UPGRADING RESEARCH

The programme to foster social science research and its applications, the title of which is MOST (the Management of Social Transformations) is to have an Intergovernmental Council of thirty-three members elected by UNESCO's General Conference, half of whom will be replaced every two years. It is also to have a Scientific Committee of nine members, who will work to expand research in the developing countries.

One of the principal underlying ideas of the programme is that of bringing researchers in the human sciences back into the decision-making process. "All too often they not only have no links with other sectors or other countries, but have no concern for the practical implications of their research either. Decision-makers too often complain that the only documents they have are incomprehensible," says Kazancigil, who pleads for an "upgrading of research".

A French researcher, Francis Godard, a leader of an interdisciplinary research programme on cities being carried out under the auspices of the French National Centre for Scientific Research (CNRS), stresses the vital importance of this question ("it is in cities that the future of human relations is being decided") and the extent to which the scientific community needs international programmes: "There is very little contact between researchers," says Godard, "and this leads to considerable wastage."

MOST is not only an English word. It also means "bridge" in Russian. ■

CULTURE

UNESCO works for the integration of culture into all areas of human activity

A SOURCE OF INSPIRATION

by Sue Williams

IN Canada, the traditional ecological knowledge of the Indian populations is being collected and documented as part of the quest for sustainable development models. In Indonesia, efforts are underway to develop a style of tourism that highlights the country's outstanding cultural heritage without damaging it. Meanwhile, in Africa a "Culture Train" is in the planning, linking Nairobi to the Cape, to promote the performing arts in the southern part of the continent. Although these are but three of a range of projects being undertaken by UNESCO's Culture Sector, they well illustrate the direction being taken for the 1994-1995 biennium, which also marks the mid-point of the World Decade for Cultural Development: to take culture out of its "ghetto" and recognize the role it plays in virtually all areas of human society.

"The objective of the Decade is to incorporate culture into all domains of activity, ranging from the economy to health and the environment," says UNESCO's Assistant Director-General for Culture, Henri Lopes, "and, in doing so, to encourage the active participation of populations in the development process."

One of the main vehicles for this will be the World Commission on Culture and Development, established at the end of 1992 and presided over by former UN Secretary-General Javier Pérez de Cuéllar. Essentially, the Commission's task is to formulate policies and practices that, according to Mr. Pérez de Cuéllar, "will lead to a more human, sustainable and unifying form of development."

The move in this direction has also led to a new emphasis on the intangible cultural heritage—traditions, skills and languages that in many places are dying out but constitute a vital part of a people's cultural identity. "This is not only a way of preserving a people's memory and knowledge," says Doudou Diene, who is in charge of intercultural projects. "Traditional crafts and forms of artistic expression have always been shaped by outside influences. Culture and cultural identity are the result of constant movement, interaction and exchange. This is a particularly important message today, when the defence of cultural identity has become a source of conflict."

Centres to study cultural identities and foster intercultural co-operation are currently being planned for the Mediterranean basin, southeast Europe, central Asia and southern Africa.

RAPID RESPONSE TEAM

The second major pole of action in the cultural domain for 1994-1995 is the preservation of the world's sites, monuments and cultural property. Here, a major reinforcement effort is underway to encourage more Member States to accede to the World Heritage Convention. The World Heritage Centre, established in 1992 to "promote and mobilize", is also refocusing its efforts to better ensure the protection of the 378 sites on the World Heritage List. "The mere listing of properties is not sufficient" says the Centre's director, Bernd von Droste. "We need more effective site management. This means systematic monitoring, which in turn means better information and documentation on sites, especially the fifteen now on the World Heritage in Danger List." It has also been decided to set up a team of specialists who can move quickly into emergency situations, such as natural disasters, and launch safeguarding operations—a sort of rapid response team for the world's natural and cultural treasures.

Given the surge in illicit art trafficking, especially in eastern Europe, the coming biennium will see the strengthening of the Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property. "Many of UNESCO's new Member States are not even aware of how the Convention works or how they can use it," says Lyndel Prott, head of UNESCO's International Standards Section. "To correct this situation, we are planning a series of seminars in West Africa, South America and central Asia, not only to inform but also to provoke some action and stem the tide of smuggling from these regions."

Despite the belt tightening that has marked the past few years, this biennium will see the budget allocated to the Culture Sector increased to $41.7 million. This reflects the priority given to this area at a time when, stresses Federico Mayor, "tensions and conflicts have a growing tendency to be cultural in origin [and] a genuine intercultural dialogue is becoming an urgent necessity." ■

TO FIND OUT MORE . . . ABOUT UNESCO

What is UNESCO? A 15-page brochure describing the Organization, its history and objectives, how it functions and what can be done to support its action.

UNESCO publishes a wide range of information material on its programme, including:

Education: *UNESCO: Worldwide action in education.* An illustrated 56-page booklet presents UNESCO's strategy to meet the challenge of Education for All (EFA). *EFA 2000* is a quarterly bulletin reporting on activities of inter-agency efforts to achieve EFA goals.

Science: *Descriptive leaflets, newsletters and other materials* are available from the secretariats of UNESCO's major scientific programmes, including the Man and the Biosphere Programme (MAB) (notably *InfoMAB*); the Intergovernmental Oceanographic Commission (IOC) (notably *International Marine Science (IMS) Newsletter*), the International Geological Correlation Programme (IGCP) and the International Hydrological Programme (IHP).

Culture: *Culture +*, newsletter of the World Decade for Cultural Development; *The World Heritage Newsletter* reports on the state of conservation of sites on the WH list and on activities of the WH Committee and the WH Centre. *The World Heritage*, a map indicating the location of sites (378 in 1993), with colour photos and details on the WH Convention and Fund.

All this material is available from the bookshop at UNESCO Headquarters, 7 place de Fontenoy, 75700 Paris, France.

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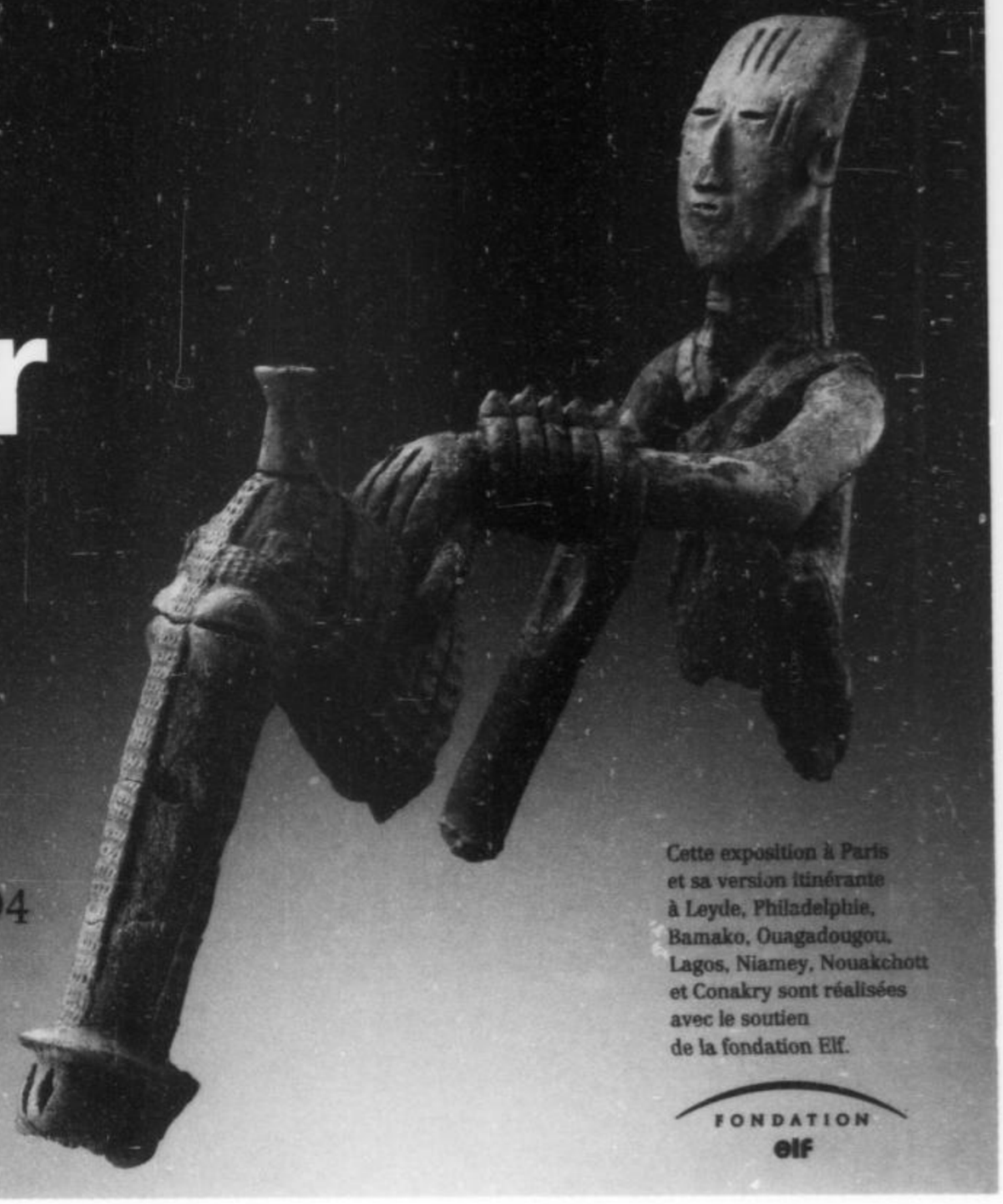

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EACH MONTH, ESSENTIAL READING FOR AN UNDERSTANDING OF THE PROBLEMS OF TODAY AND TOMORROW

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TELE...VISIONS ... THE CHALLENGE OF DEMOCRACY ... THE COMPETITIVE WORLD OF SPORT ... EXPLORING THE COSMOS ... VIOLENCE ... PSYCHOANALYSIS: THE HIDDEN I ... A TIME TO LOVE ... WATER OF LIFE ... MINORITIES... WHAT IS MODERN?... RHYTHM, GESTURE AND THE SACRED... TIME TO DISARM... THE STORY OF NUMBERS...

EACH MONTH: AN INTERVIEW WITH A PERSONALITY FROM THE WORLD OF ART, LITERATURE, SCIENCE, CULTURE...

FRANÇOIS MITTERRAND ... JORGE AMADO ... RICHARD ATTENBOROUGH ... JEAN-CLAUDE CARRIÈRE ... JEAN LACOUTURE ... FEDERICO MAYOR ... NAGUIB MAHFOUZ ... SEMBENE OUSMANE ... ANDREI VOZNESENSKY ... FRÉDÉRIC ROSSIF ... HINNERK BRUHNS ... CAMILO JOSE CELA ... VACLAV HAVEL ... SERGEI S. AVERINTSEV ... ERNESTO SÁBATO ... GRO HARLEM BRUNDTLAND ... CLAUDE LÉVI-STRAUSS ... LEOPOLDO ZEA ... PAULO FREIRE ... DANIEL J. BOORSTIN ... FRANÇOIS JACOB ... MANU DIBANGO ... FAROUK HOSNY ... SADRUDDIN AGA KHAN ... JORGE LAVELLI ... LÉON SCHWARTZENBERG ... TAHAR BEN JELLOUN ... GABRIEL GARCÍA MÁRQUEZ ... JACQUES-YVES COUSTEAU ... MELINA MERCOURI ... CARLOS FUENTES ... JOSEPH KI-ZERBO ... VANDANA SHIVA ... WILLIAM STYRON ... OSCAR NIEMEYER ... MIKIS THEODORAKIS ... ATAHUALPA YUPANQUI ... HERVÉ BOURGES ... ABDEL RAHMAN EL BACHA ... SUSANA RINALDI ... HUBERT REEVES ... JOSÉ CARRERAS ... A LETTER FROM FREUD TO EINSTEIN ... LUC FERRY ... CHARLES MALAMOUD ... UMBERTO ECO ... OLIVER STONE... ANDRÉ BRINK... JAMES D. WATSON... AMOS OZ...

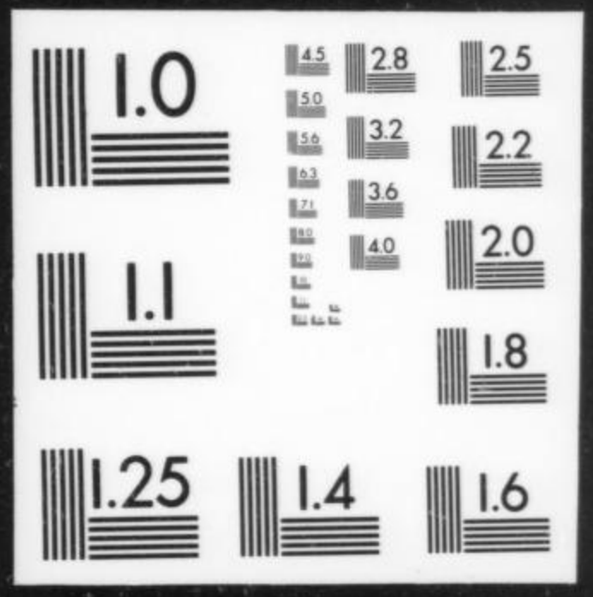
EACH MONTH: REGULAR FEATURES ON THE ENVIRONMENT, THE WORLD HERITAGE, UNESCO ACTIVITIES WORLDWIDE...

THEME OF THE NEXT ISSUE (DECEMBER 1993):

THE MEANING OF PROGRESS: A NORTH-SOUTH DEBATE

ALSO FEATURING AN INTERVIEW WITH THE FRENCH PHILOSOPHER

MICHEL SERRES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